WSDOT

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I-90: Four Lakes to Idaho Stateline

Operations Study

EXISTING CONDITIONS FINAL REPORT

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INTRODUCTION

Interstate 90 (I-90) through the Spokane region was completed in 1974, and since that time, the region has come to rely upon the interstate as an essential transportation corridor for the regional and interstate movement of people and goods. As the region's population grew, traffic volumes increased on I-90. Higher traffic volumes, combined with crashes, construction work zones and other incidents have increased the operational strain on I-90.

The I-90: Four Lakes to Idaho Stateline Operations Study details current issues and needs and develops an operations strategy for improving safety and managing traffic flow within the I-90 corridor over the next ten years. In this study, practical solutions that maximize benefits for travelers without adding new lanes to I-90 will be examined. This report describes the existing corridor conditions including corridor travel characteristics, crashes and incidents, transportation system management and operations activities, and planned/funded projects.

KEY FINDINGS

The existing conditions analysis identified both safety and travel time reliability as the primary concerns for the I-90 corridor through the Spokane metropolitan region.

Safety Findings

- **Crashes on I-90 have steadily increased over the past five years.** Crashes increased 22 percent between 2011 and 2015 in the study corridor. Crashes contribute significantly to non-recurring traffic congestion on I-90.
- **Crashes occur almost daily on I-90.** Between 2011 and 2015, the I-90 corridor experienced 3,600 crashes. The increasing number of crashes create unpredictable travel times for autos, transit and freight.
- **I-90 on- and off-ramp traffic regularly queues onto the mainline at some interchanges.** As traffic volumes continue to increase, queues form on the off-ramps with vehicles backing onto I-90. The ramp queues create a safety hazard by increasing the likelihood of rear-end crashes. Locations where queuing has been observed include:
    - Eastbound off-ramp at Division
    - Westbound off-ramp at Maple/Walnut
    - Eastbound off-ramp at Maple/Walnut
    - Westbound Lincoln off-ramp
- **Many I-90 on- and off-ramps experience a higher than expected number of crashes**. Closely spaced interchanges along with short weave and merge areas on the mainline, particularly through downtown Spokane, contribute to the higher than expected volume of crashes. The following locations are crash hotspots:
    - Eastbound on-ramp from US 195 (short acceleration and merge area)
    - Eastbound and westbound on-ramps at the Hamilton interchange (short weave area)

- Eastbound on-ramp from Freya (short acceleration and merge area)
- Interchange at Exit 280: Maple/4th/Walnut/Division including on-ramps, off-ramps and terminals intersections (short spacing between on- and off-ramps)
- Interchange at Exit 281: Division/Browne Street including on-ramps, off-ramps and terminals intersections (observed queueing spilling onto mainline)

- **Weather and poor driving behavior contribute to the majority of I-90 crashes.** Inclement weather, exceeding a reasonably safe speed, and following too closely represent 84 percent of the contributing factors to crashes.
- **Rear-end, sideswipe and fixed object crashes occur most frequently on I-90**. Rear-end and sideswipe crashes make up 59 percent of total crashes between 2011 and 2015. Crashes with a fixed object are the third most common crash type accounting for 30 percent of the total.
- **Driving under the influence (DUI) is the leading cause of high severity crashes on I-90.** Close to 25 percent of all high severity crashes are DUI-related.

Travel Reliability Findings

- **Traffic volumes are steadily increasing on I-90**. Between 2012 and 2015 traffic volumes rose by an average of 10 percent in the corridor.
- **Traffic patterns have a distinctive peak travel direction**. Westbound traffic volumes rise during the morning rush hour and eastbound volumes rise in the evening rush hour. Congestion and reliability issues are more likely to occur westbound in the mornings and eastbound in the evenings.
- **Incidents are a growing cause of unreliable travel times on I-90.** Over the last five years, unplanned incidents along the corridor increased by 40 percent. Incidents includes crashes along with other reported events such as disabled vehicles, debris on the roadway, and construction or maintenance events that disrupt the normal flow of traffic.

CORRIDOR CHARACTERISTICS

The project study corridor comprises a 30-mile corridor of I-90 through the Spokane metropolitan area, from the southwest where it connects to SR 904, through the cities of Spokane, Spokane Valley, and Liberty Lake to the east where it meets the Idaho border. For analysis of the corridor operations, four distinct segments, labeled segments A through D, are used because they reflect different land use (urban/rural) and traffic volume characteristics. Figure 1 illustrates the project limits from Four Lakes, west of Spokane, to the Washington/Idaho state line, and distinguishes the analysis segments.

This section presents the corridor characteristics organized by the four segments, including roadway characteristics, traffic volumes, travel time reliability, and a summary of WSDOT's most recent Corridor Capacity Report.

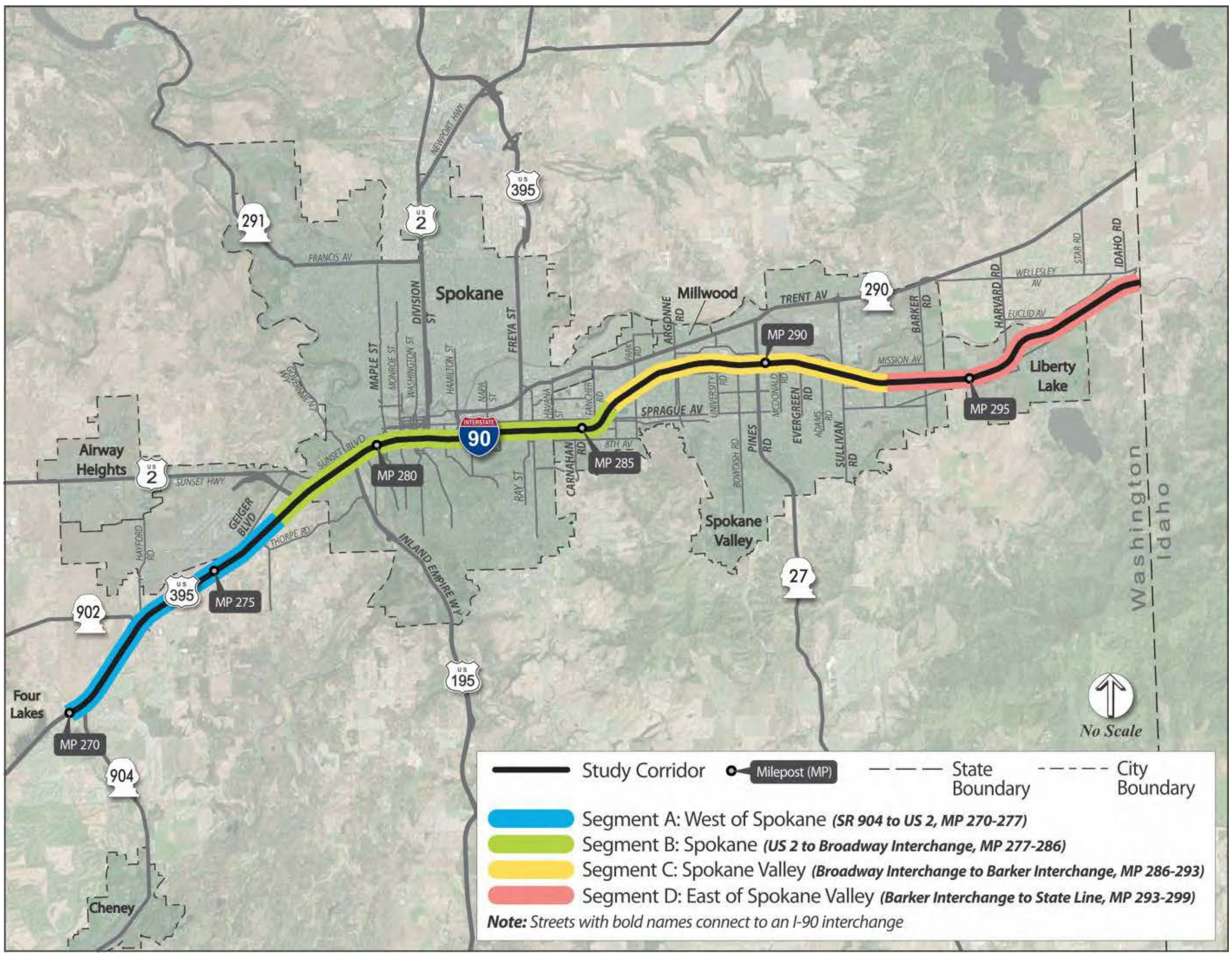

Figure 1. I-90 Corridor Study Area

Roadway Characteristics

Table 1 shows some of the typical roadway characteristics for each study segment including length, posted speed, lanes, shoulders, ramps, interchange spacing, type of median, and any other unique characteristics.

Along segments A and D, most of I-90 has shoulders available for disabled vehicles, appropriate spacing between interchanges[1], and grassy medians. In segments B and C, the interchanges are closely spaced with short weave and merge areas, there are limited or no shoulders through some areas, and the median is a concrete barrier which limits emergency vehicle access and inside shoulder width.

Table 1: Corridor Segment Roadway Characteristics

	Segment A: West of Spokane (MP 270-277)	Segment B: Spokane (MP 277- 286)	Segment C: Spokane Valley (MP 286-293)	Segment D: E. of Spokane Valley (MP 293-299)
Segment Length*	6.8 miles	8.6 miles	7.8 miles	5.8 miles
Posted Speed	70 mph (60 mph for trucks)	60 mph	60 mph	70 mph (60 mph for trucks)
Lanes (per direction)	2-3	3-5	3-4	2
Shoulders	Yes (inside and outside)	Some outside shoulders. No parking, tow away zone.	Yes (outside)	Yes (outside mainly)
Number of Entrance Ramps	Eastbound - 4 Westbound - 4	Eastbound - 9 Westbound - 9	Eastbound - 4 Westbound - 6	Eastbound – 4 Westbound – 3
Interchange Spacing	1 to 4 miles	< 1 to 2 miles	< 1 to 2 miles	2 to 3 miles
Median Barrier	Concrete or grassy median	Concrete	Concrete	Cable barrier or grassy median
Unique Characteristics	N/A	5% downgrade eastbound (approx. MP 277 to 279)	N/A	N/A

*The milepost range used for each segment is rounded and the segment length represents the mileage of the segment.

Figure 2 (2a and 2b) displays the lane geometry and interchange spacing for the I-90 corridor. WSDOT design manual requirements between on-off ramps for weaving is a minimum of 1,000 feet, and 800 feet between two

[1] The WSDOT design manual defines standard interchange spacing as one-mile minimum spacing between interchanges in urban areas, and three mile spacing in rural areas. (WSDOT Design Manual. M22-01.12. Section 1360.02. November 2015.)

off-ramps or two on-ramps. Eleven merge and weave areas along the corridor do not meet current performance expectations due to short spacing. Table 2 lists the eleven areas by segment.

Table 2: Merge and Weave Areas Not Meeting Performance Expectations

Segment A: West of Spokane (MP 270-277)	
Location	**Lane Geometry and/or Spacing Issues**
Westbound between the Grove Rd on-ramp and Geiger Blvd on-ramp	Short merge area
Segment B: Spokane (MP 277- 286)	
Location	**Lane Geometry and/or Spacing Issues**
Eastbound on-ramp from I-195	Short acceleration and merge area
Eastbound on-ramp from Maple/Walnut	Short distance between the on-ramp from Maple/Walnut and from Lincoln/Monroe
Eastbound between Hamilton on-ramp and Altamont off-ramp (Exit 283A)	Short weave area
Eastbound between Altamont on-ramp and Freya off-ramp (Exit 283B)	Short weave area
Eastbound on-ramp from Freya	Short acceleration/merge area
Westbound between Freya on-ramp and Altamont off-ramp (Exit 283A)	Short weave area
Westbound between Altamont on-ramp and Hamilton off-ramp (Exit 282B)	Short weave area
Westbound between Exit 282B off-ramp and Exit 282A off-ramp	Short spacing between off-ramps
Westbound between Division Street on Exit 280B	Short weave area
Westbound between Exit 280B and Exit 280A	Short spacing between off-ramps

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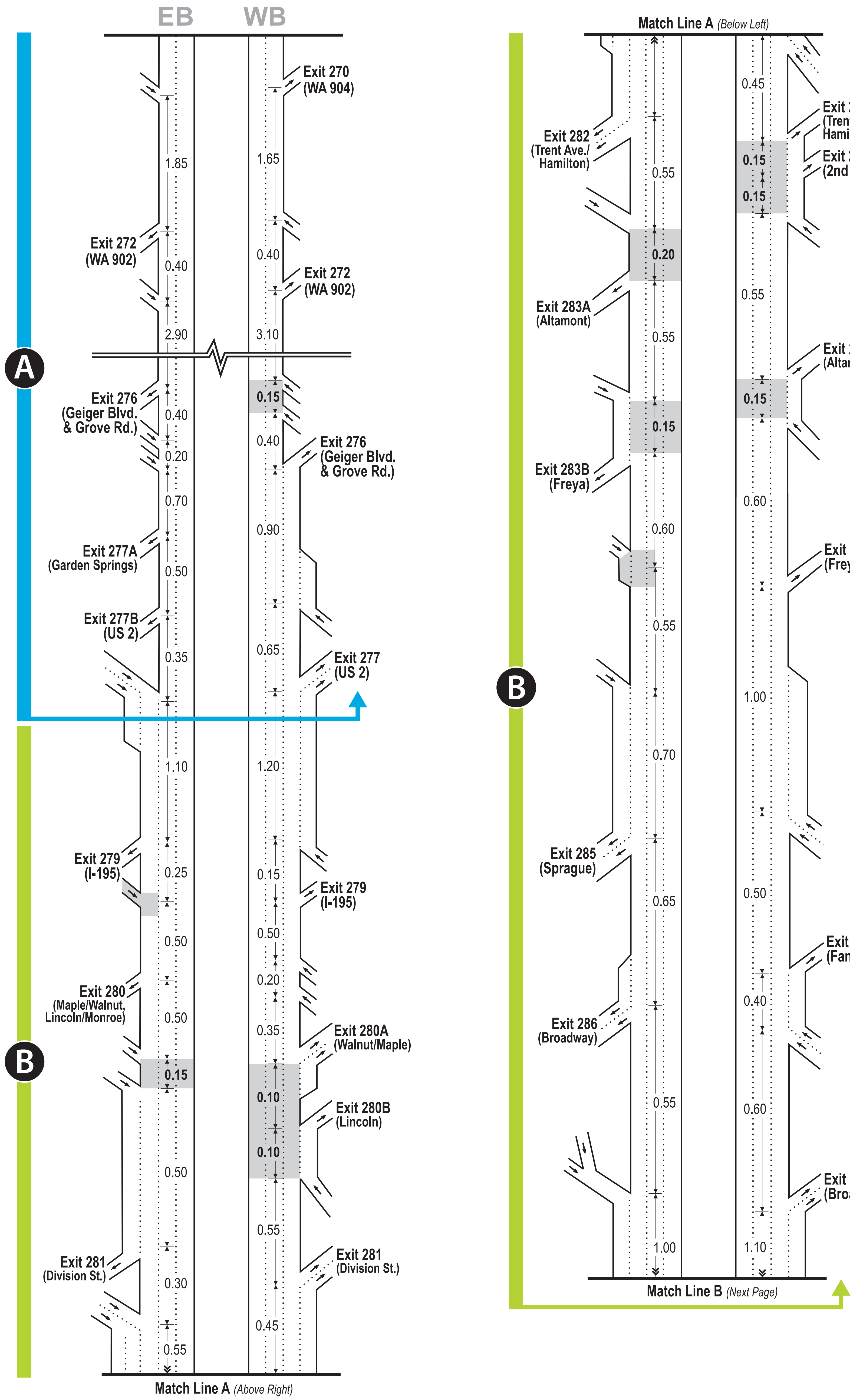

NOT TO SCALE

LEGEND

- X - Segment (Color Coded)
- 0.00 - Distance In Miles Between Interchange Gore Areas (Rounded to Nearest 0.05)
- 0.00 - Merge or Weave Areas That Do Not Meet Current Performance Expectations or Have Observed Safety Problems

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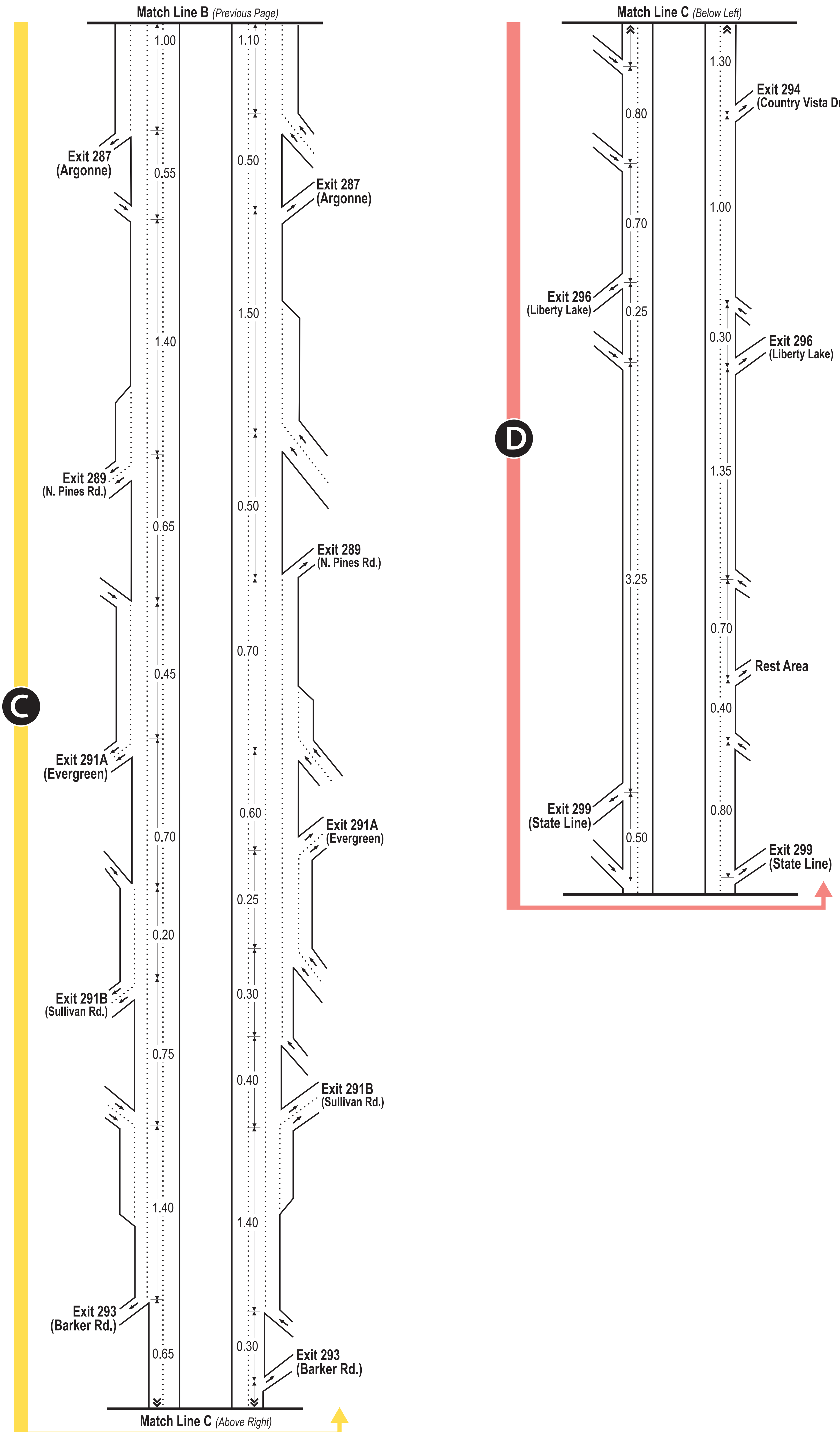
Figure 2a

I-90 Lane Geometry & Interchange Spacing



NOT TO SCALE

LEGEND

X - Segment (Color Coded)

0.00 - Distance In Miles Between Interchange Gore Areas (Rounded to Nearest 0.05)

0.00 - Merge or Weave Areas That Do Not Meet Current Performance Expectations or Have Observed Safety Problems

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Figure **2b**

I-90 Lane Geometry & Interchange Spacing

Traffic Volumes

Traffic volumes on I-90 increased by more than 10% in each direction over the last four years, which contributes to decreased travel time reliability.

Between 2012 and 2015, traffic volumes along I-90 increased by approximately 10 percent in each direction. Figure 3 illustrates the growth in traffic volumes in each of the corridor's four segments.

- Segment B, through downtown Spokane, experienced the highest westbound growth rate with a nearly 16 percent increase in westbound traffic volumes and nearly a 12 percent increase in eastbound traffic volumes.
- Segment D, east of Spokane Valley, experienced the largest percentage increase in eastbound traffic volumes with an increase over 13 percent.

Figure 4 illustrates the average hourly and daily traffic volumes along the corridor's four segments. Volumes are based on data from 2012 to 2014.

- Segment B, through downtown Spokane, experiences the highest traffic volumes on the corridor with more than 85,000 vehicles per day. Segment A, west of Spokane, experiences the lowest traffic volumes with over 30,000 vehicles per day.
- Morning peak volumes show a westbound commute-related directionality, evening peak volumes show an eastbound commute-related directionality, and midday traffic volumes are balanced. This suggests that congestion and reliability issues are more likely to occur westbound in the mornings and eastbound in the evenings

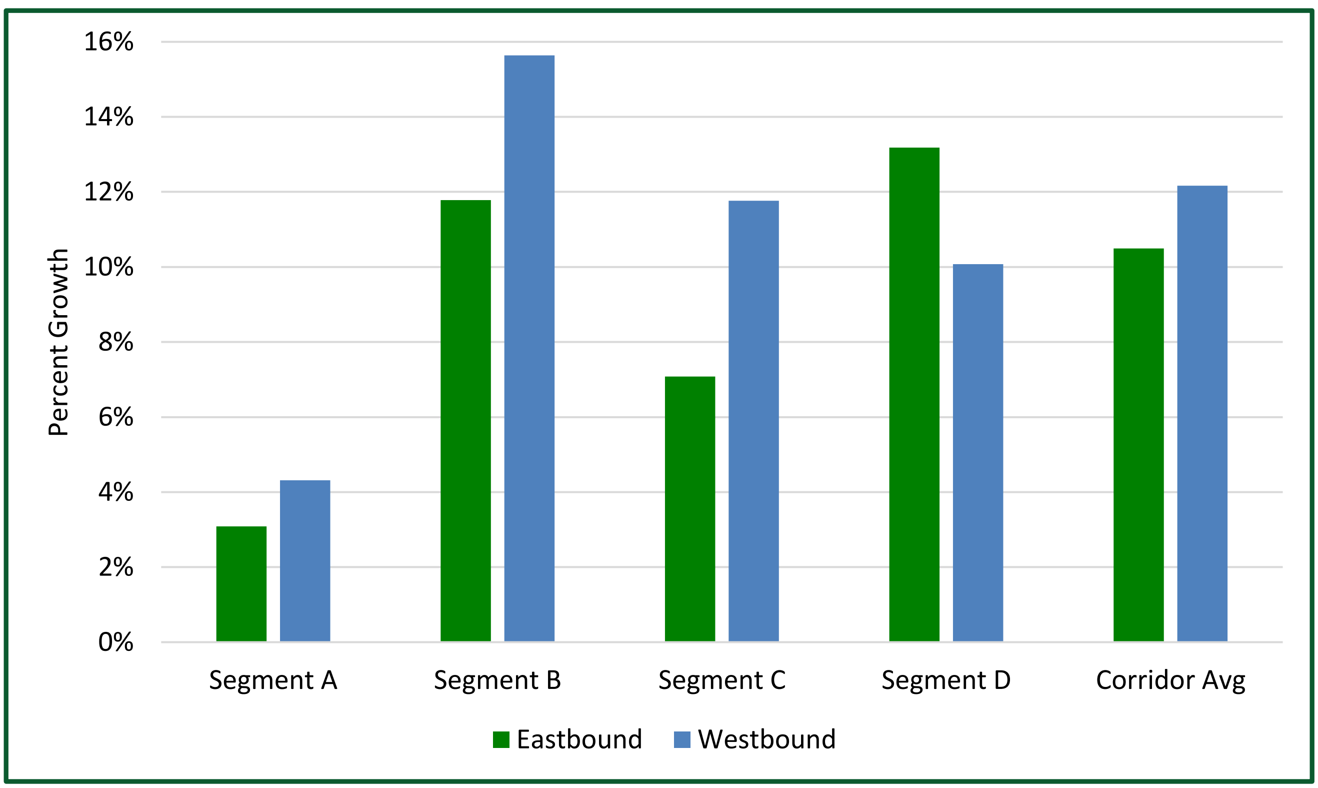

Figure 3: Traffic Volume Change Between 2012 and 2015 (*Data Source: PeMS*)

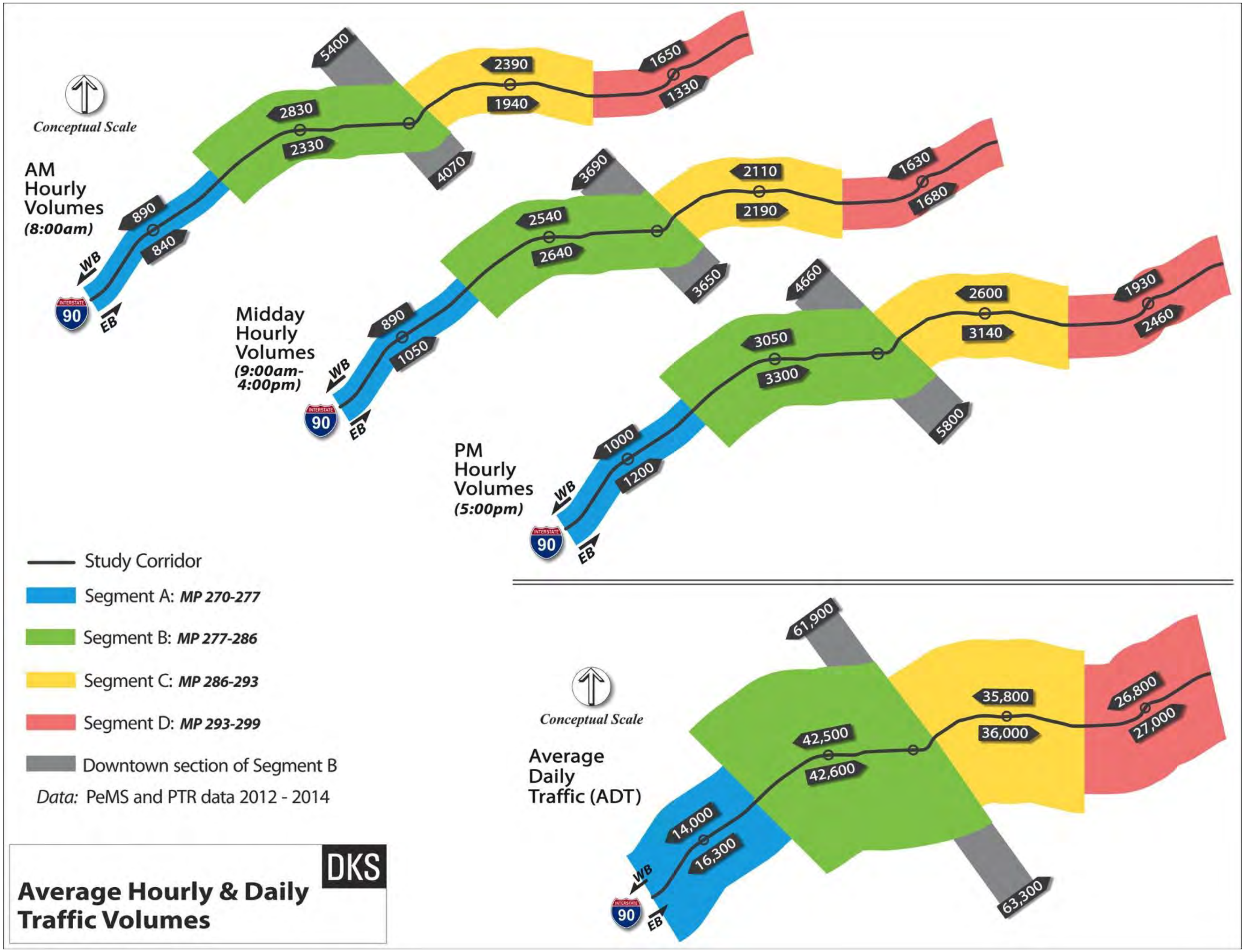

Figure 4: Average Hourly & Daily Traffic Volumes

Travel Time Reliability

Travel time reliability is a measure of how consistent travel times are from day to day. Drivers want to know that their travel time will be consistent from one day to the next, and tend to remember the days when travel time is longer than normal. The travel time reliability measure is also a good indicator of the amount of delay caused by congestion and or unexpected incidents.

In addition to heavy volumes during peak periods, many other factors affect the safe and efficient flow of traffic on I-90. Examples are shown in Figure 5.

For this analysis, planning time is used to determine the reliability of trips on I-90 in the a.m., midday, and p.m. peak time periods. Planning time is a measure of how much time is necessary to ensure on-time arrival 95 percent of the time, and is an indicator of congested conditions. For example, if a trip normally takes 20 minutes, but the 95th percentile travel time is 32 minutes, then the traveler must plan to leave 32 minutes prior to arrival to ensure on-time arrival. The closer the planning time is to the average travel time, the less congested the trip.

Travel time and traffic volume trends for are shown by segment in Figure 6 through Figure 9.

Figure 5: Additional factors affecting travel time

Segment A provides access to Spokane International Airport and the communities west of downtown Spokane. As illustrated in Figure 6, it experiences the least amount of variation in travel times for any of the segments. Although traffic volumes between 2012 and 2015 have increased 9% in the eastbound p.m. peak direction, travel time reliability has remained the same.

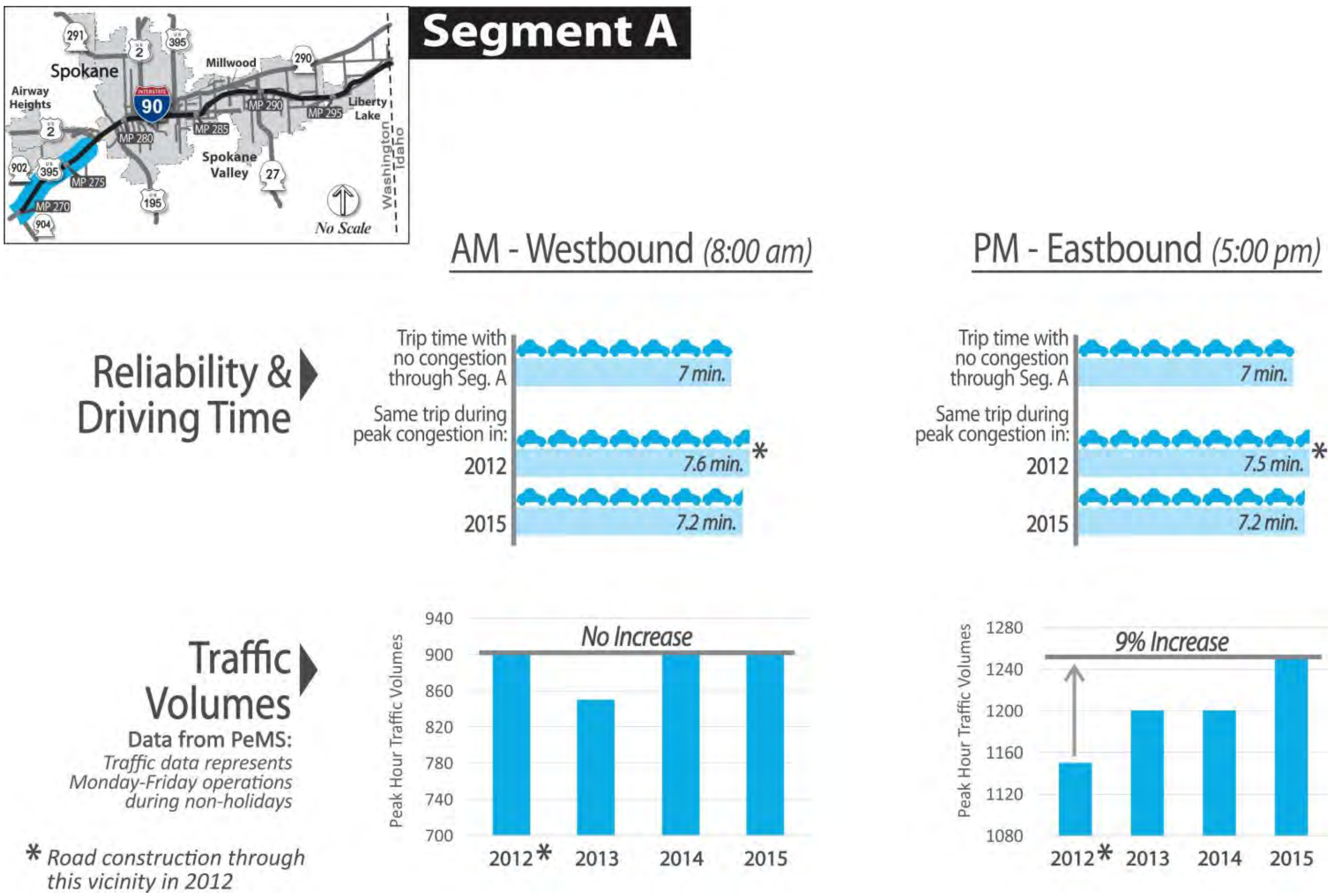

Figure 6: Travel Time Reliability for Segment A

Segment B, through downtown Spokane, experiences the greatest variation in travel times for any of the segments. As illustrated in Figure 7, during the a.m. peak period, westbound travelers must plan an additional 1.5 minutes to ensure on-time arrival 95 percent of the time, and eastbound travelers during the p.m. peak period must plan over three minutes of additional travel time.

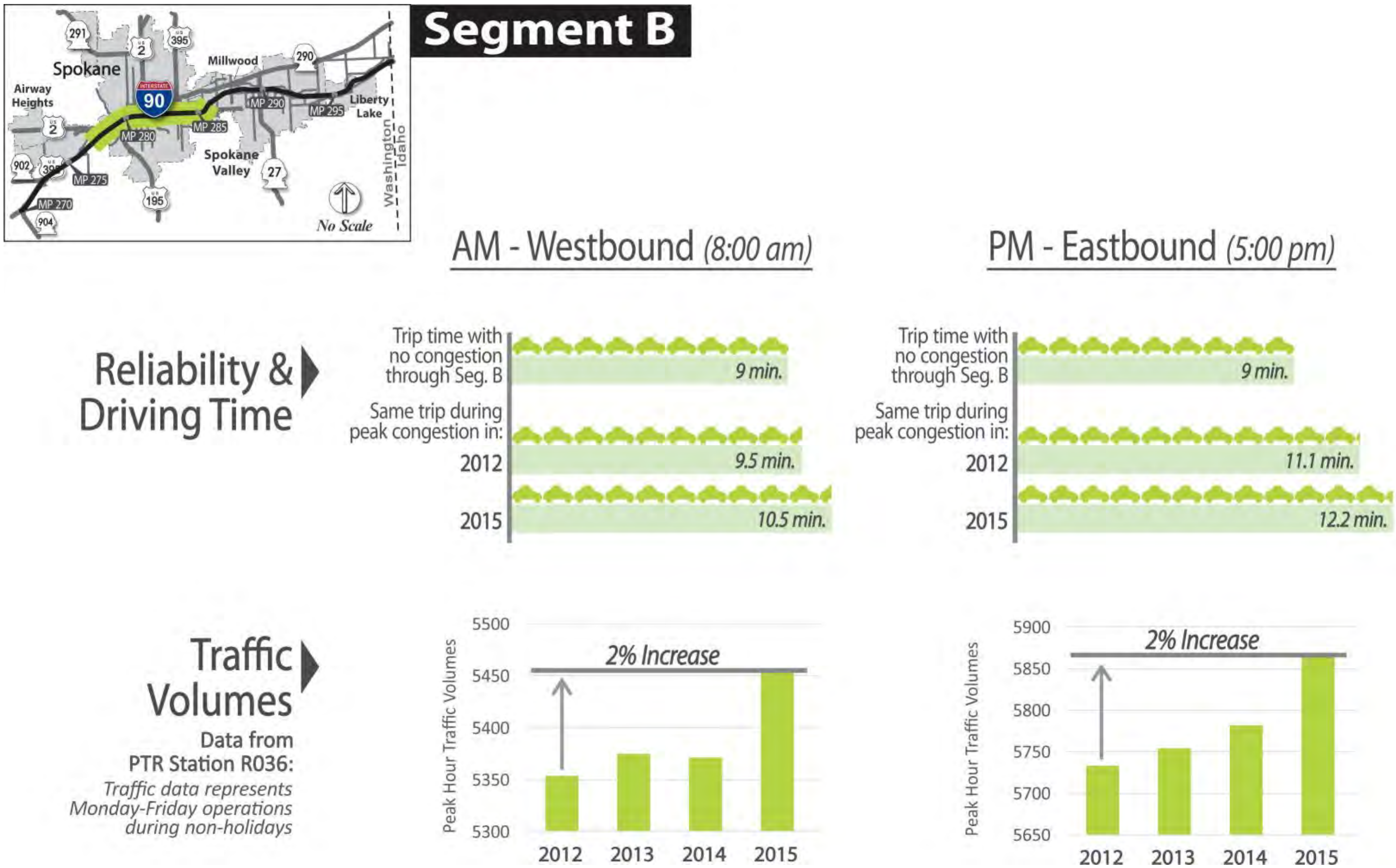

Figure 7. Travel Time Reliability for Segment B

Segment C, Spokane Valley, has experienced significant growth in traffic volumes, and, as illustrated in Figure 8, motorists must plan more than one minute of additional travel time in the p.m. peak to ensure on-time arrival 95 percent of the time.

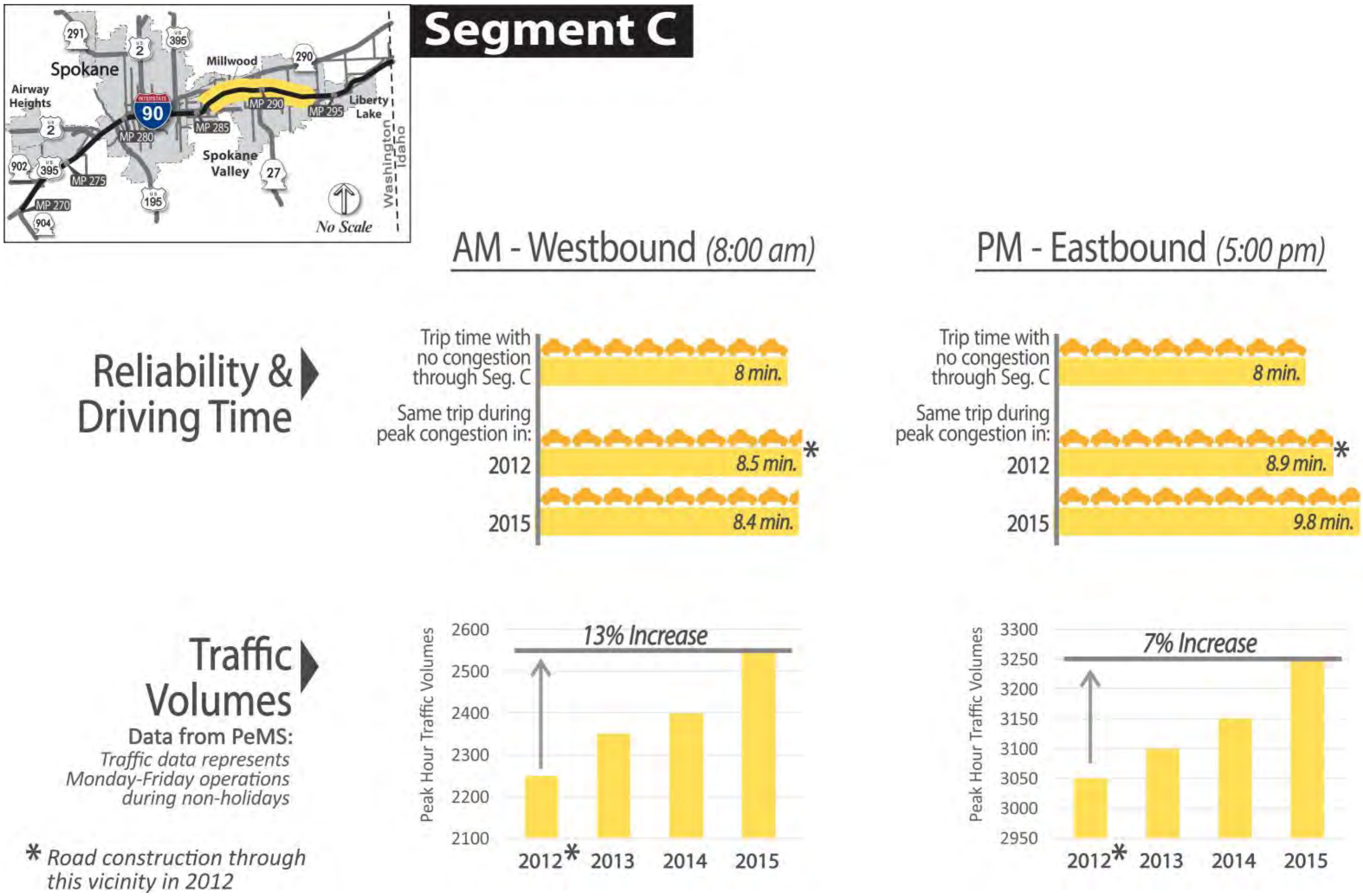

Figure 8. Travel Time Reliability for Segment C

Segment D, east of Spokane Valley, has experienced significant growth in traffic volumes, and, as illustrated in Figure 9, motorists must plan one additional minute of travel time to ensure on-time arrival 95 percent of the time in both the westbound and eastbound directions.

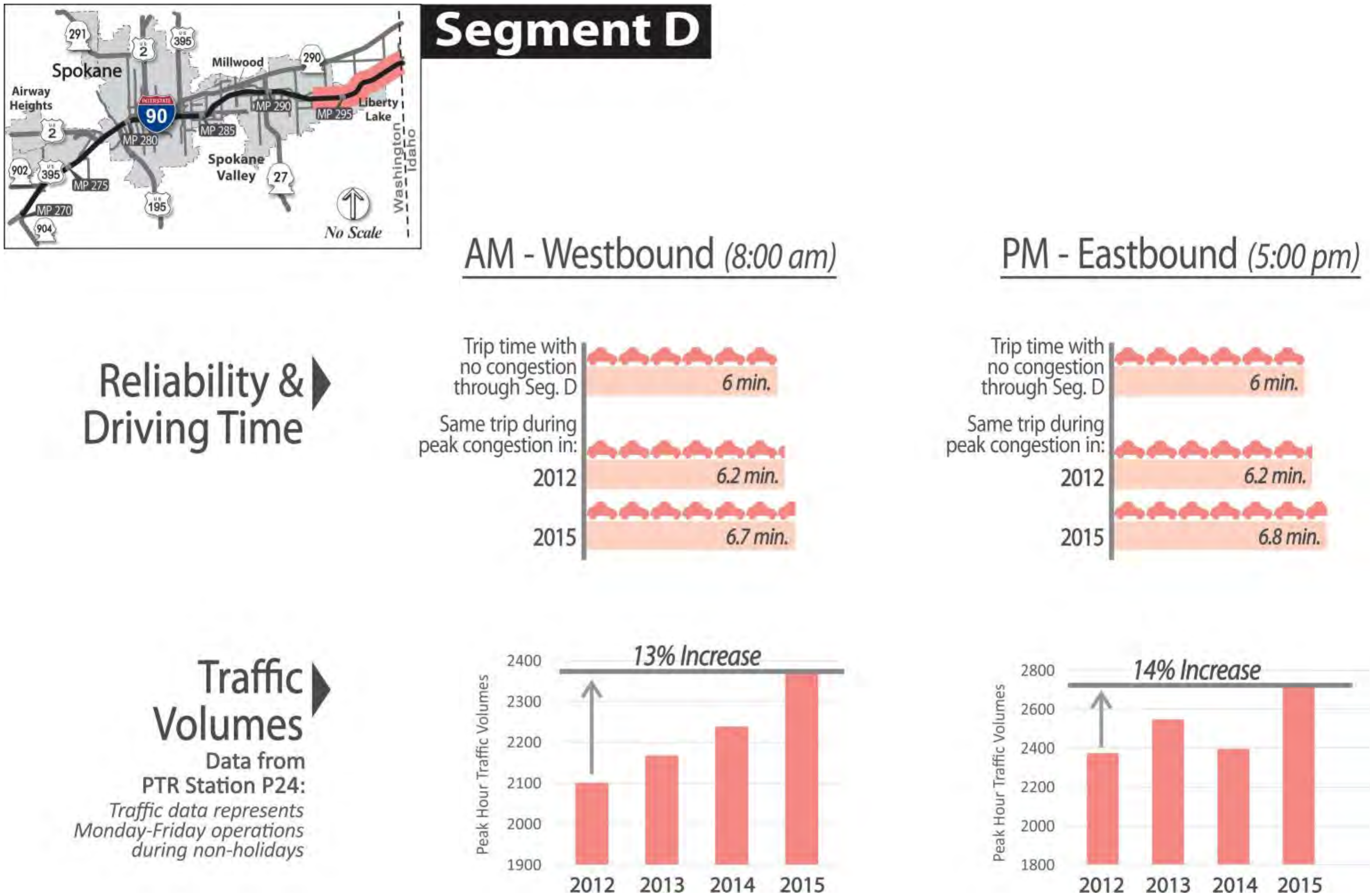

Figure 9. Travel Time Reliability for Segment D

WSDOT Corridor Capacity Summary

WSDOT publishes the Corridor Capacity Report annually[2], which documents performance measures on the state's highway system. For the I-90 Spokane area, the report focuses on the segment of I-90 from Division Street to Argonne Road. The most recent publication from 2016 uses data from 2013 and 2015, and identified the following key findings that are relevant to the corridor system management and operations:

- Annual vehicle delay increased by 99 percent (from 40.6 to 80.6 thousand hours). Contributing factors include increased traffic volumes, and increased crashes from 190 in 2013, to 225 in 2015. (*Note that WSDOT defines vehicle delay as when average speeds are slower than 85 percent of the posted speed limit.)*
- Average a.m. peak hour westbound travel time increased from 9 to 10 minutes. The planning time, which is the amount of time necessary to arrive on-time 95 percent of the time, remained steady at 12 minutes.
- Average p.m. peak hour eastbound travel time remained steady at 10 minutes, yet the planning time increased from 13 to 15 minutes, which indicates the p.m. peak eastbound travel time has become less reliable.
- During the p.m. peak hour typical eastbound congestion from Division Street extended 3.8 miles and lasted 60 minutes, an increase of 3.3 miles and 35 minutes compared to 2013.
- During the a.m. peak hour typical westbound congestion increased by 1.0 mile and lasted 10 minutes longer compared to 2013.
- For westbound travel there was up to a 32 percent chance of experiencing congestion during peak weekday commute periods; for eastbound travel there was up to a 44 percent chance of experiencing congestion during peak weekday commute periods.
- In the westbound direction, travelers had a 5 percent chance of encountering severe congestion, which WSDOT defines as speeds slower than 36 mph, during peak commute periods.
- In the eastbound direction, travelers had a 20 percent chance of encountering severe congestion during peak commute periods.

TRANSPORTATION SYSTEM MANAGEMENT AND OPERATIONS ACTIVITIES

WSDOT uses both intelligent transportation systems (ITS) and transportation demand management (TDM) strategies within the I-90 corridor to actively manage traffic flow, respond to the impact of incidents, evaluate roadway operations and support travel choices. Using a combined set of tools to monitor, measure and communicate traffic conditions allows WSDOT to take an active approach to traffic management in the corridor.

This section provides an overview of existing intelligent transportation system (ITS) and transportation demand management (TDM) strategies currently used.

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[2] The Draft 2016 Corridor Capacity Report. The 15th Edition of the annual Congestion Report. Washington State Department of Transportation. Nov 2016. http://www.wsdot.wa.gov/Accountability/Congestion/2015.htm

ITS Devices in the Corridor

A suite of ITS components, as shown in Figure 10, are in place on I-90 today that monitor, measure and communicate traffic conditions. Figure 11 and Figure 12 show where these types of devices are located along the I-90 corridor.

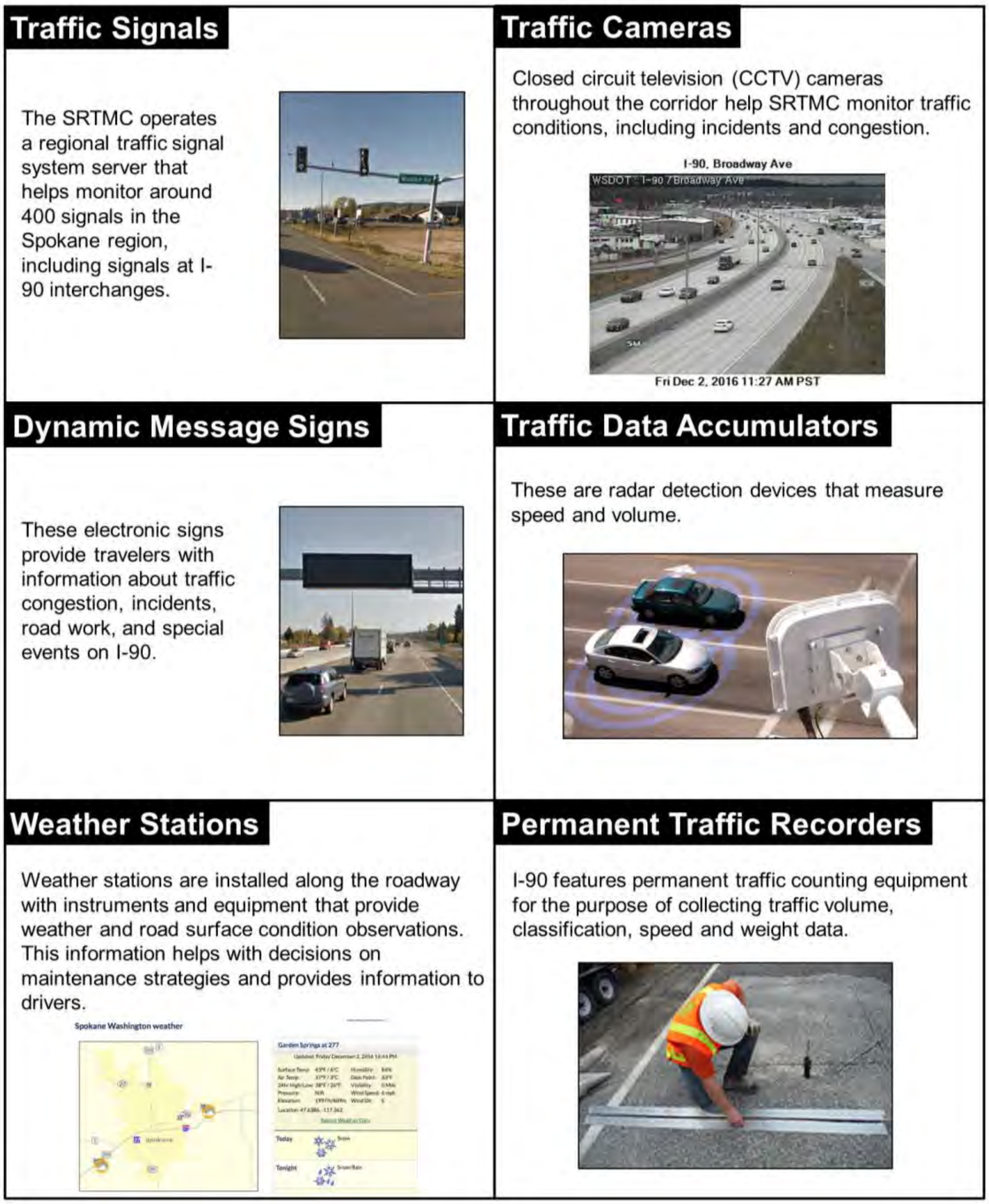


Figure 10: ITS devices in the corridor

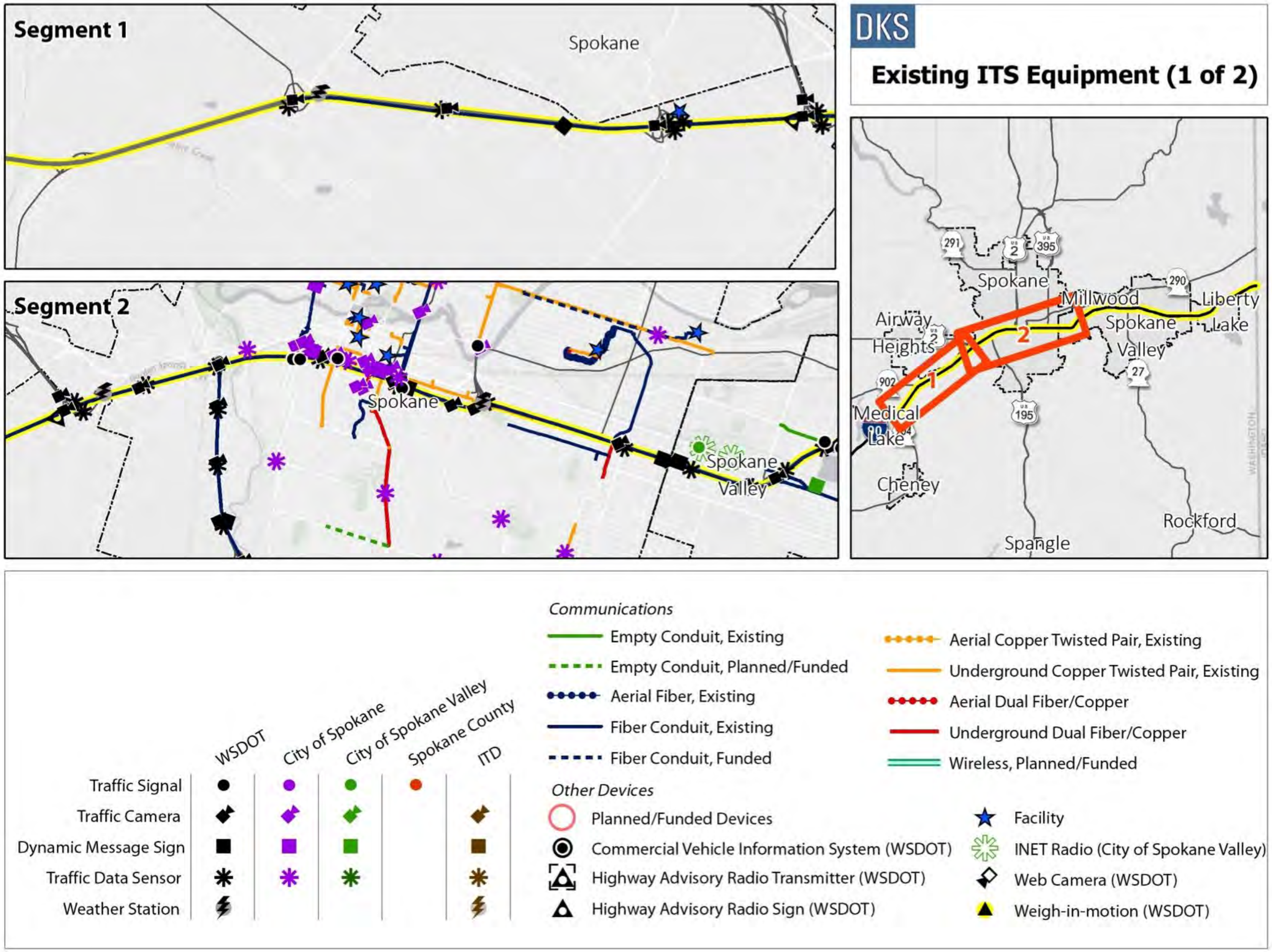


Figure 11: Existing ITS Equipment (1 of 2)

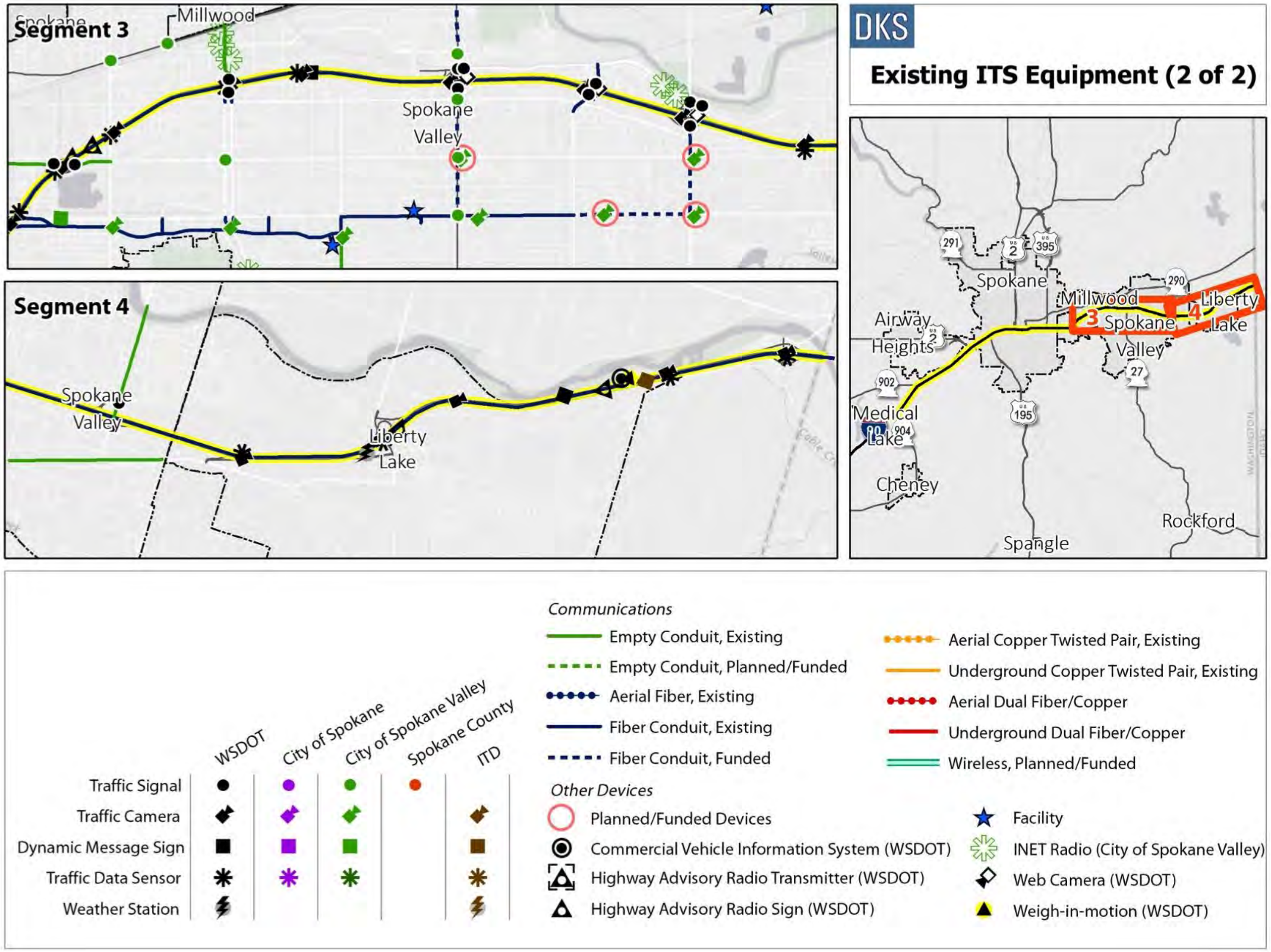


Figure 12: Existing ITS Equipment (2 of 2)

Transportation Demand Management Programs

Transportation Demand Management (TDM) is an approach to reduce congestion and improve mobility through policies and programs.

In Spokane County, Commute Trip Reduction (CTR) alternatives are promoted by the county, which administers the regional CTR program[3]. The county works with hundreds of employers to match employees with alternative transportation rather than driving a single-occupant vehicle. The CTR program promotes biking, walking, transit, carpool/vanpool, compressed work weeks, and telecommuting.

As the population increases in Spokane County and along the I-90 corridor, the CTR program's important role in managing demand on the transportation system will continue.

Spokane Regional Traffic Management Center (SRTMC)

SRTMC is a team of professionals working 24/7 with multiple jurisdictions to deliver reliable transportation information services, locally and regionally, to create a safe and efficient travel experience for everyone.

TMC operators staff the center around the clock, year-round, evaluating and reacting to events that impact travel and roadway safety. By notifying responders and posting information to the web, 511, and email/text alerts, SRTMC operators help to reduce congestion and collisions.

By linking the infrastructure and technology resources of the agency partners who make up the SRTMC, those organizations are better able to support each other through equipment sharing and incident coordination.

With more than 100 live streaming camera feeds available, 23 electronic variable message signs, 10 highway advisory radio (HAR) AM transmitters, various intelligent transportation system devices such as volume/speed detectors, and hundreds of traffic signals, the SRTMC is the hub of the region's transportation management system.

Incident Response Program

WSDOT calls their dedicated incident response program Dedicated Roving Patrols. They respond to incidents along I-90 between WA 904 (milepost 270) and the Washington/Idaho state line (milepost 299). In addition to I-90, the dedicated roving patrols respond to calls from the Washington State Police on all state routes within the Greater Spokane Area which includes: Spokane County, Whitman County, Stevens County, Pend Oreille County and occasionally Adams County.

The Dedicated Roving Patrols operate three trucks and have two full time drivers. The program is hoping to add a third full time driver in the summer of 2017 to work during peak commute around and weekend. The patrols operate on two daily shifts Monday through Friday: morning 5:30 a.m. to 1:30 p.m., and evening 12:30 p.m. to 8:30 p.m. Weekends and holidays are covered using "call-outs".

[3] http://www.mycommute.org/

INCIDENT AND CRASH EVALUATION

As a busy urban corridor, incidents along I-90 are frequent occurrences that endanger travelers and contribute to non-recurring congestion and unreliable travel times. This section presents information on the incidents occurring in the corridor, 89% of which were categorized as something other than a collision. This section also presents finding from crash data and results from the predictive safety analysis conducted for I-90. The purpose of the evaluation is to identify high crash locations (hot spots), common crash types, and contributing factors to inform the development of safety countermeasures. Ultimately, this project will define proposed strategies aimed at reducing the number of crashes and incidents along the I-90 corridor, as well as improving clearance times when crashes and incidents do occur.

The crash and incident evaluation examines crash data from WSDOT crash reports, incident data from WSDOT's incident records database, and uses a predictive safety analysis to determine crash hot spots and predict locations that have a higher potential for crashes.

WSDOT Incident Data Analysis

WSDOT Incident data includes crashes, as well as other events such as disabled vehicles, debris on the roadway, construction or maintenance events, and dead animals that impact roadways. Incidents are reported to the Spokane Regional Traffic Management Center (SRTMC) by maintenance personnel or Washington State Police (WSP), or detected on a TMC camera feed. While not every roadway incident is reported, this data set provides valuable insight into event types, frequency, locations, and other trends that future strategies can address.

The SRTMC logs incidents on I-90. The project team evaluated five years of incidents (2011 through 2015) to identify trends that could indicate an operational need on the corridor.

Table 3 shows the percentage of capacity lost when lanes are effectively closed by an incident. An incident need not block a travel lane to generate a loss in capacity that increases travel delay and creates a safety hazard.

Table 3: Freeway Capacity Changes

Number of Highway Lanes	Percent Facility Capacity Lost by Blockage Type			
	Shoulder	1 Lane	2 Lanes	3 Lanes
2 Lanes	19%	65%	100%	N/A
3 Lanes	17%	51%	83%	100%
4 Lanes	15%	42%	75%	87%

Source: Transportation Research Board. Highway Capacity Manual, 2010.

The following list defines some of the more common event types observed on the study corridor:

- Disabled Vehicle – A blocking or non-blocking vehicle that is unable to move without assistance and is attended by at least one person.
- Abandoned Vehicle – Any vehicle that is not occupied and left unattended on a right-of-way.

- Collision – Single or multi-vehicle collision, on or off the roadway (e.g. crash, or accident)
- Debris – A foreign object blocking or not blocking the roadway which will require removal by road crews or law enforcement.
- Pedestrian - Person walking, hitch hiking, standing, or biking on the right-of-way and requiring a response to remove from the right-of-way.
- Other Incident – Any event not covered by other event types.
- Lane Closure – Any WSDOT, City, County, Valley, contract, or WSP-designated lane closure for one or both directions of the roadway.
- Construction – Construction-related lane and road closures, or other construction info worthy of logging. May alternatively be categorized as lane closure.
- Maintenance – Work such as striping, drain cleaning, barrier repairs, pothole fixes, fencing, and other duties routinely performed by road maintenance crews.
- Closure – Any WSDOT, City, County, Valley, contract, or WSP-designated road closure in one or both directions of a roadway.
- Fire – Any building, structure, trees, brush, or other material on fire potentially or actually impacting travel. Vehicle fires are separate.
- Vehicle Fire – A vehicle that has visible flames or smoke caused by fire.
- Signs – Issues with roadway signs, e.g. knocked down, leaning, missing, dirty, vandalized.
- Trees – Trees that are blocking all or part of a roadway, or affecting power and phone lines, or leaning in such a way that they may be a hazard to motorists.
- Signals – All signal device events; outages, signals in flash mode, not cycling properly, and signal or light pole knock-downs due to weather or collision. This also applies to cameras, DMS, and HAR equipment.
- Dead Animal – Report of a dead animal on or near the roadway that needs to be removed.
- Medical Emergency – Medical emergencies reported to TMC or observed via CCTV, such as a slumped driver, intoxication, heat exhaustion/stroke, fainting, or other calls for medical aid.

Between 2011 and 2015, 19,390 incidents occurred along the study corridor; the equivalent of roughly 10 incidents per day over the 30-mile corridor. The incidents locations were equally divided between travel directions (9,357 eastbound and 9,189 westbound). In some instances, the location was unknown or noted as "both".

Table 4 shows the incident type, frequency of each type of incident and direction of travel where the event occurred. The incident is recorded as "both" when it impacts travel in the eastbound and westbound direction. Table 4 breaks out incidents that represent greater than 1 percent of the total. Some event types such as "Bridge" and "Medical Emergency" accounted for less than 1 percent of the total incidents and are included in the "Other/Unknown" category.

The most frequent type of incident was a disabled or abandoned vehicle, which commonly takes up a shoulder lane (if a shoulder is present) and can reduce capacity by 15 to 19 percent, depending on the number of lanes (see Table 3). Aside from the "unknown/other" category, which accounted for 25 percent of all incidents, the next most common type was a collision, accounting for 11 percent of all incidents, followed by debris (9 percent) and then maintenance and construction activities (6 percent).

Table 4: Incident Types (2011-2015)

Type of Incident	Total Number by Type	Percentage by Type	Direction Impacted			
			Eastbound	Westbound	Both	Unknown
Disabled or Abandoned Vehicle	7267	37%	3500	3500	210	57
Other/Unknown	4784	25%	2302	2268	174	40
Collision	2161	11%	1039	1015	84	23
Debris	1795	9%	905	811	62	17
Maintenance/ Construction	1130	6%	532	541	46	11
Pedestrian	873	5%	417	422	28	6
Dead Animal	227	1%	118	98	9	2
Signals	238	1%	105	110	19	4
Lane Closure	180	1%	91	77	12	0
Complaint	131	1%	76	48	7	0
Signs	149	1%	72	72	3	2
Fire	127	1%	50	68	8	1
Closure	101	1%	46	49	4	2

Figure 13 shows the distribution of incidents between 2011 and 2015. Over the five years evaluated, the number of incidents on I-90 increased by about 40 percent.

Incidents increased by 40% over the last five years, which contributes to decreased travel time reliability.

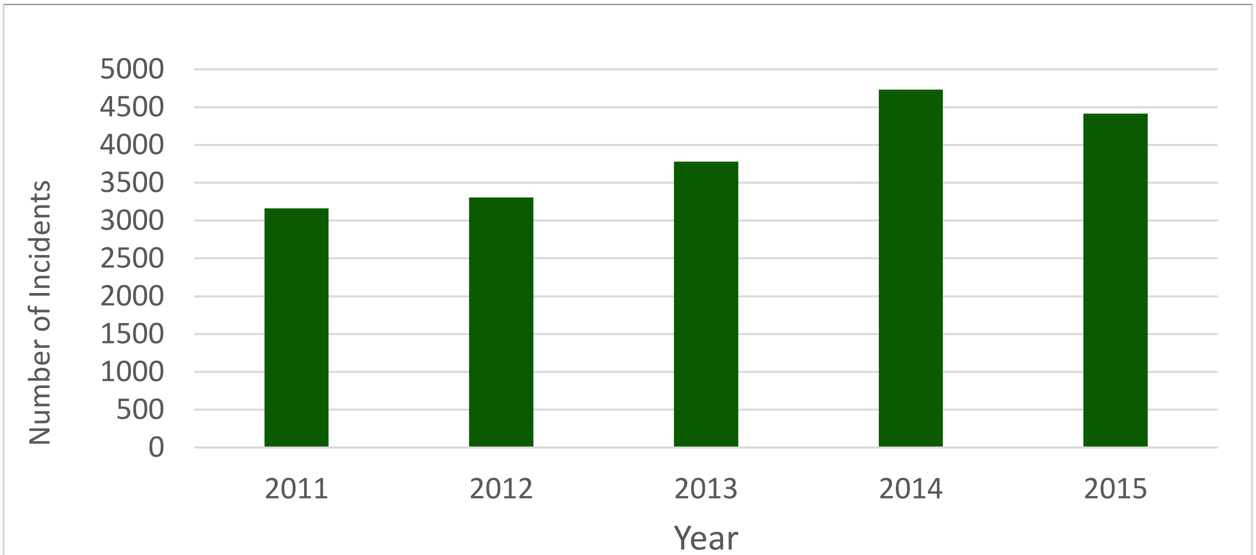


Figure 13: Total Incidents by Year

Figure 14 shows total incidents by month between 2011 and 2015. The number of reported incidents peak during the summer months (June, July, and August).

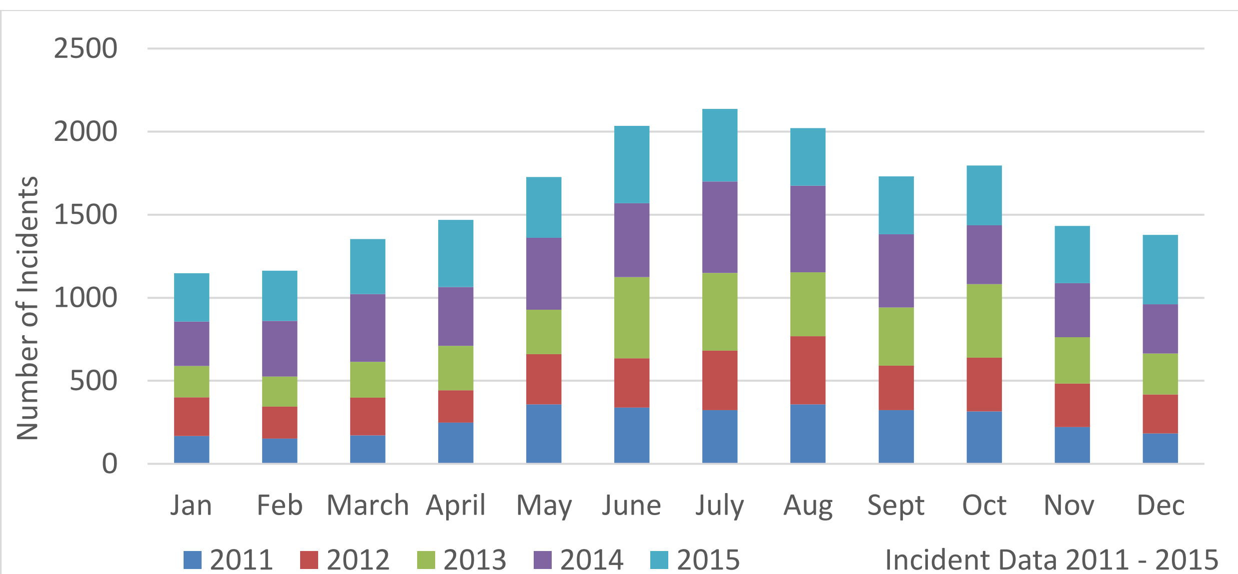


Figure 14: Total Incidents by Month

Figure 15 shows the total incidents over five years by milepost and direction. Incidents spike between mileposts 279 to 283, which correlates to the section of I-90 through downtown Spokane.

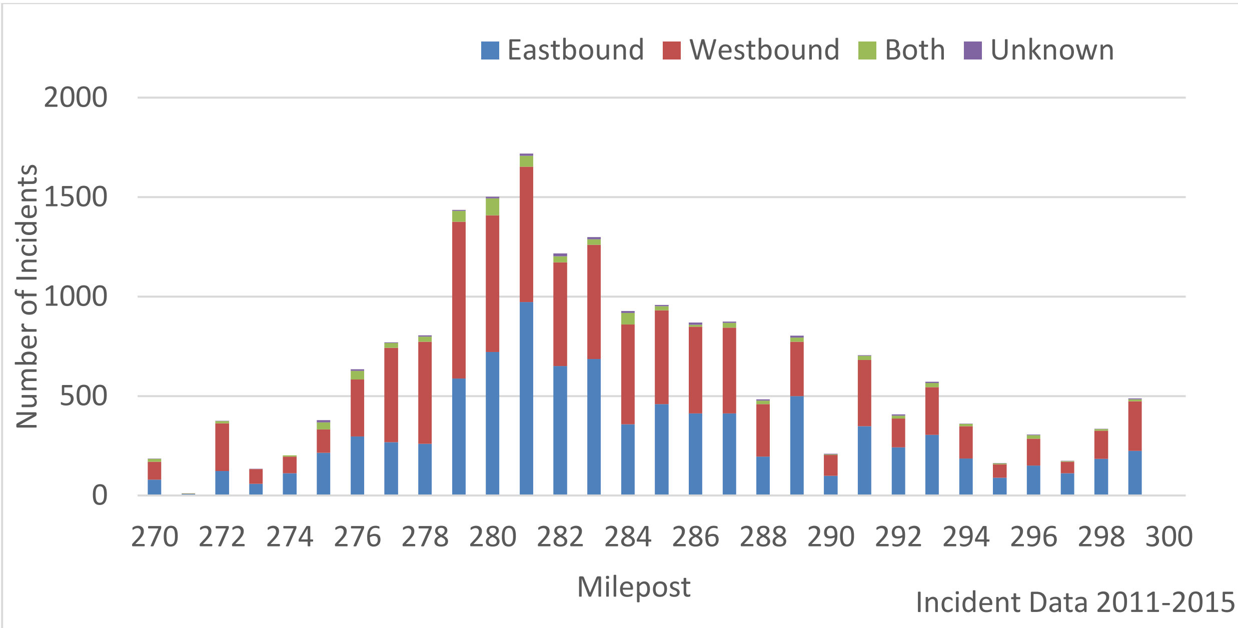


Figure 15: Incidents by Milepost and Direction

Figure 16 shows the distribution of debris events along the I-90 corridor. The occurrence of debris on the roadway spikes between Rosamond Ave (MP 279) and Broadway (MP 287). Roadway debris, particularly in the travel lanes, poses a safety hazard to travelers.

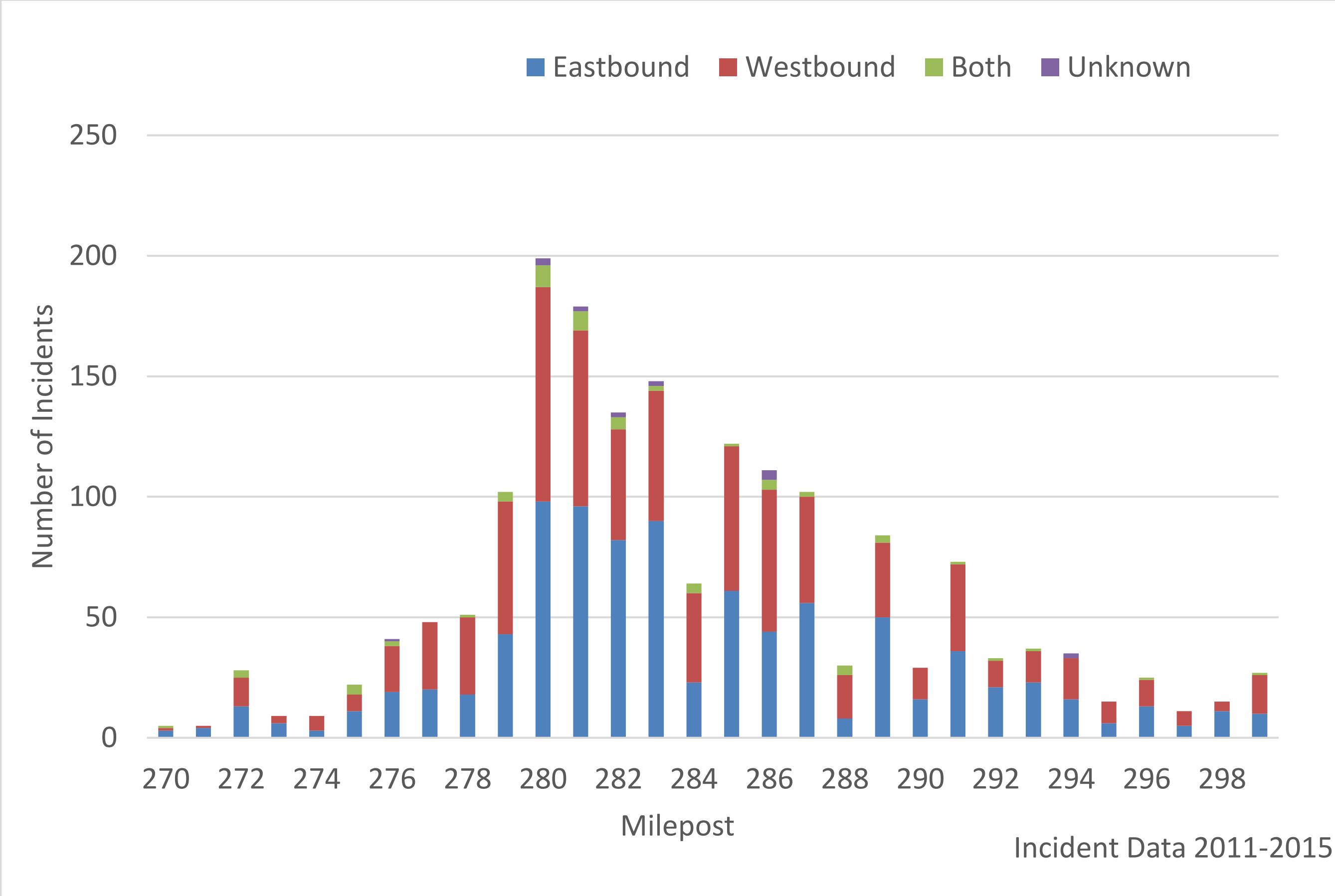


Figure 16: Debris Events by Milepost

Crash Analysis

The WSDOT Crash Data and Reporting Branch provides geocoded crash records based on officer-reported motor vehicle crashes on State facilities. This section presents an overview of the crash locations, contributing circumstances, and trends present in the I-90 study corridor crash records collected for the most recent five complete years (2011 to 2015).[4]

Between 2011 and 2015, I-90 mainline experienced 2,392 total crashes. Year-to-year crash totals have been steadily rising. Since 2012, I-90 crashes increased 22 percent as illustrated in Figure 17. An additional 1,307 crashes occurred on the interchange ramps and at the ramp terminals during the same five-year period. In total, the I-90 corridor including ramps and ramp terminals experienced 3,699 total

In 2011 there were 172 work zone crashes during an extensive rehabilitation project, far more than the typical 20 per year. This increase in work zone crashes contributed to a higher overall number of crashes, and does not portray the increasing trend since 2012.

[4] Under 23 United States Code, Section 409, this data cannot be used in discovery or as evidence at trial in any action for damages against the WSDOT or any jurisdictions involved in the data.

crashes between 2011 and 2015, which is an average of 740 crashes per year or approximately two crashes per day in the corridor.

On the I-90 mainline, eight crashes resulted in a fatality and 17 resulted in a serious injury, as detailed by year in Figure 18. Reviewing the data reveals that fatal crashes decreased from four in 2011 to remain steady at one per year since 2012. The serious injury crashes show a decreasing trend from 2011 through 2014, but then increase in 2015. Of the eight fatalities that occurred between 2011 and 2015, all eight occurred during dark conditions, five involved drivers under the influence of alcohol, drugs, or medication, three involved a vehicle driving the wrong way, and three involved a pedestrian.

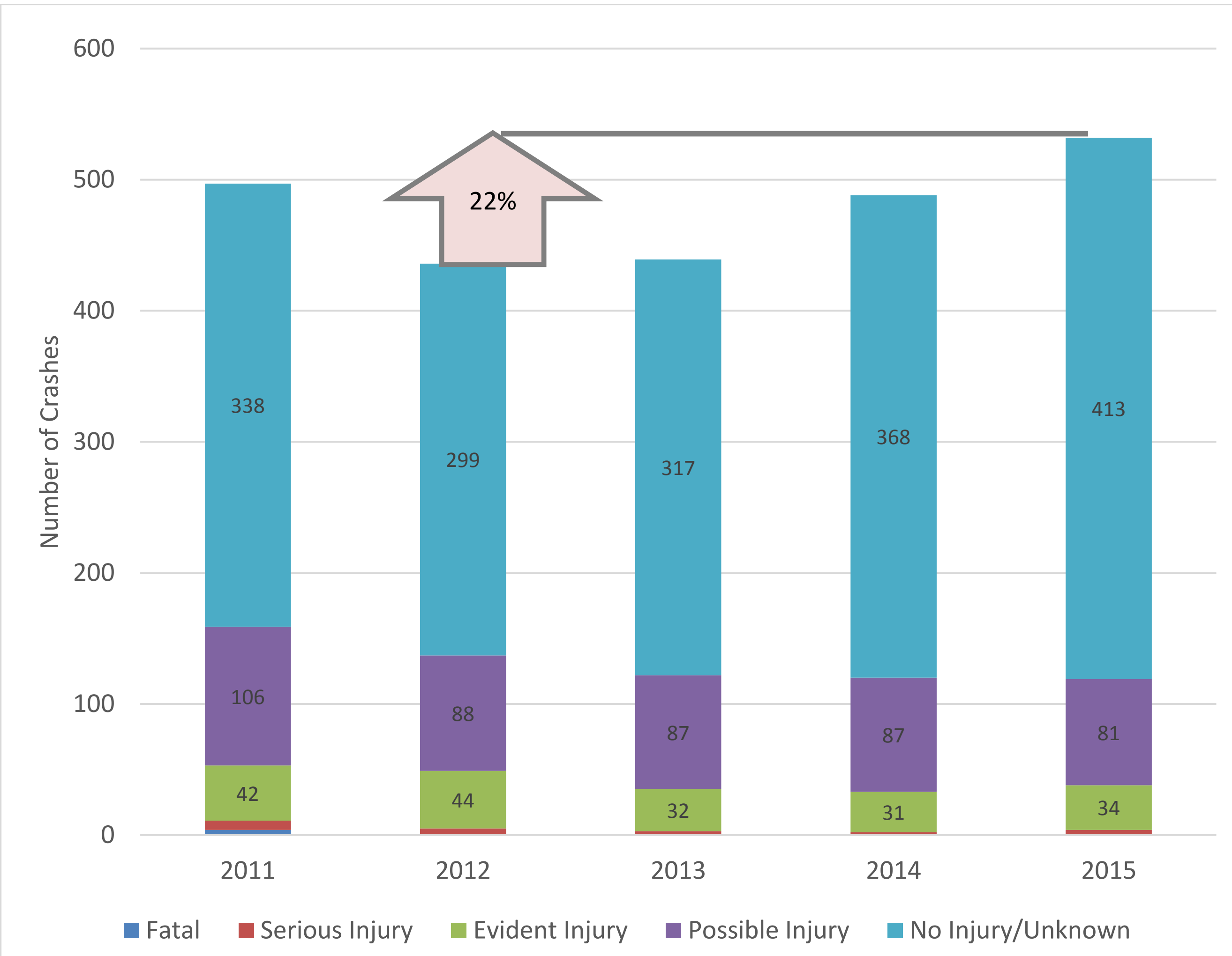


Figure 17: I-90 Mainline Crashes by Year and Severity

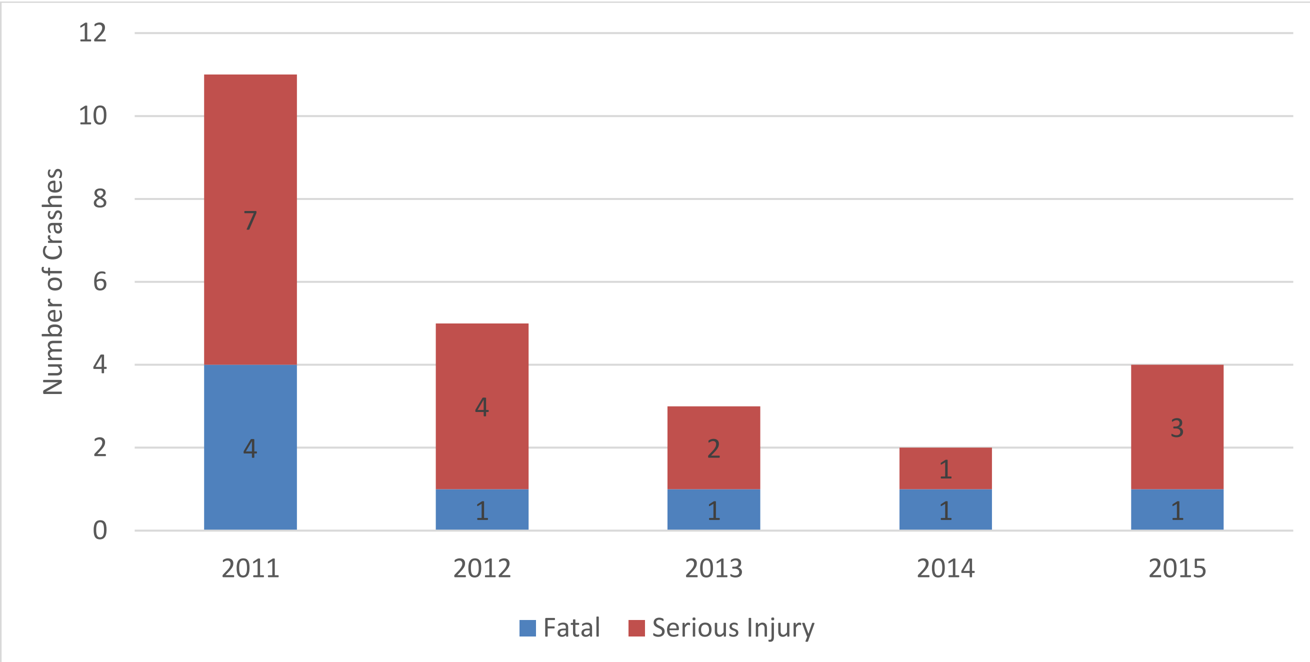


Figure 18: I-90 Mainline Fatal and Serious Injury Crashes

Work Zone Crashes

Over the five years analyzed, there was a total of 234 work zone related crashes on the I-90 mainline, as shown in Figure 19. In 2011 a particularly high number of work zone related crashes occurred (172 on the mainline), which contributes to the higher overall number of crashes in 2011 compared to the other years. Work zone crashes involve both crashes that occur within a work zone as well as crashes that occur due to a backup from a work zone. During 2011 there was an extensive rehabilitation project. Of the seven serious injury crashes in 2011, four involved work zones. In following years, the work zone crashes were generally less than 25 on the mainline and five or less on the ramps.

Almost 25 percent of all work zone crashes occurred around milepost 279, near the US-195 interchange. Two thirds of which occurred in the eastbound direction, as shown in Figure 20. At milepost 279 there were a total of 58 crashes over the five years analyzed. Of those 58 crashes, 51 occurred in 2011 during the extensive rehabilitation project.

A majority of the work zone crashes were rear-end crashes (70%). Side swipes were the second most common crash type (16%).

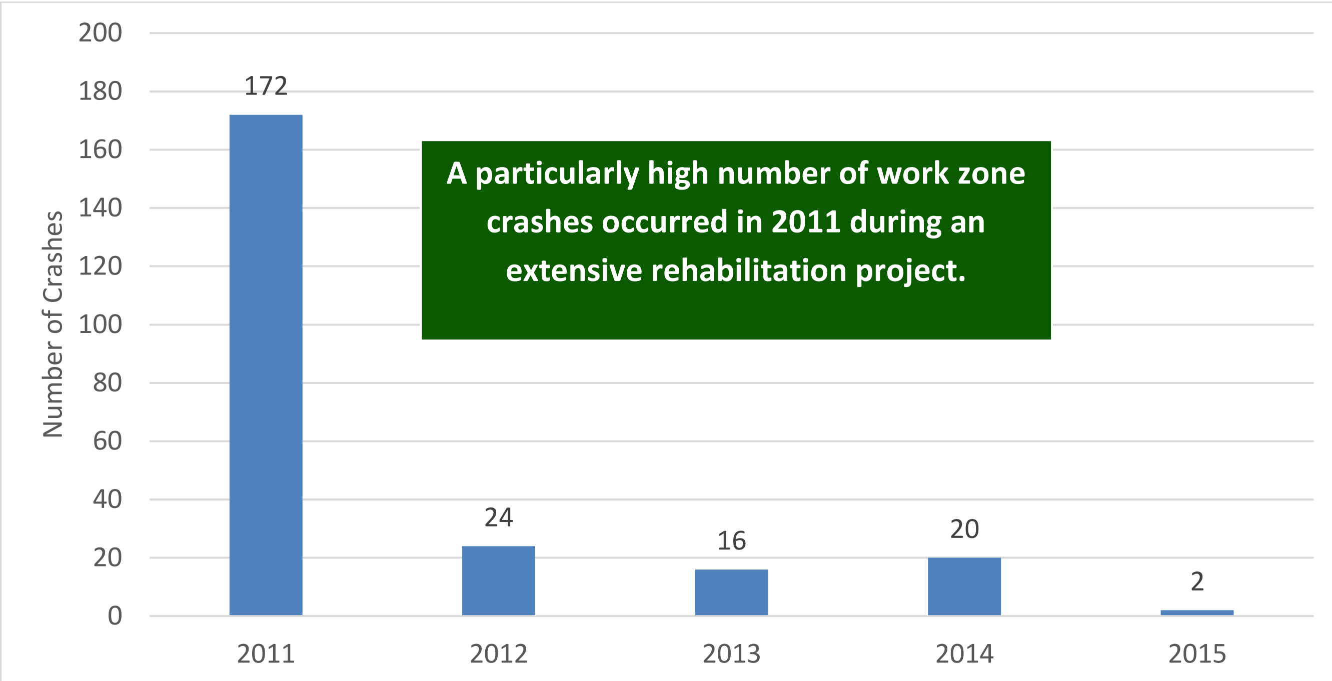


Figure 19: Work Zone Crashes on I-90 Mainline

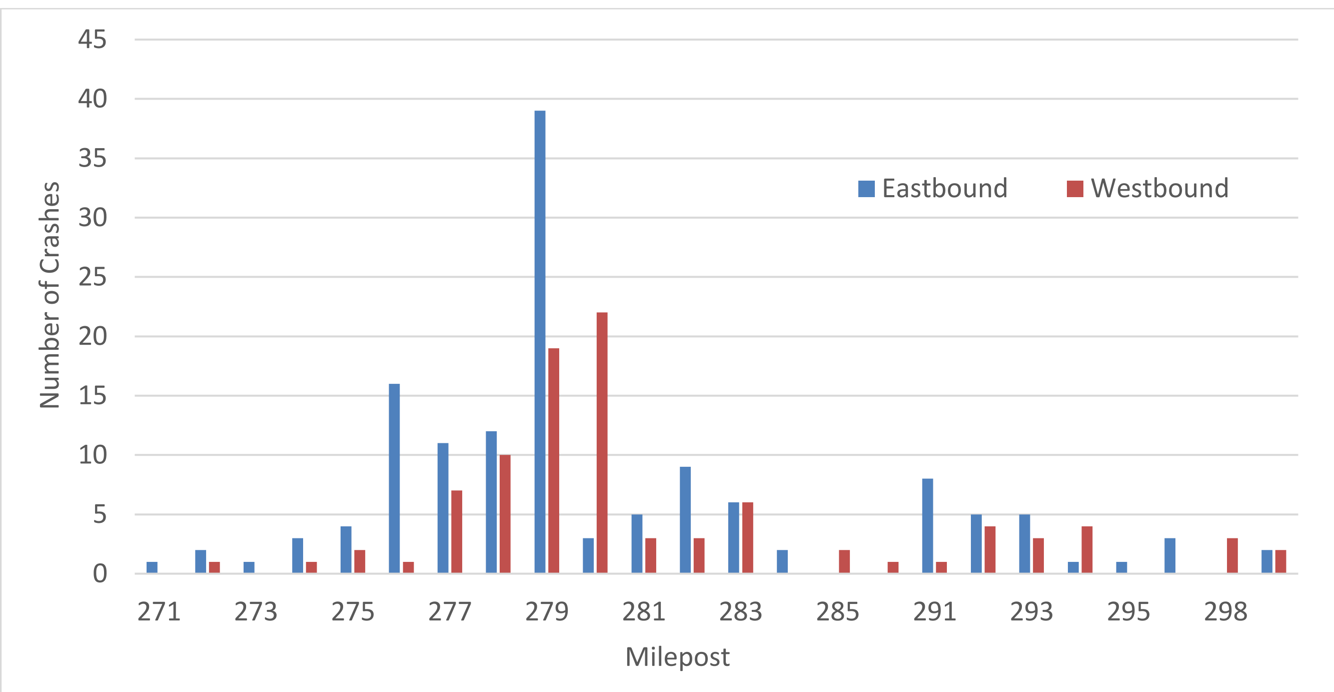


Figure 20: Work Zone Crashes by Milepost

Crash Type

On the I-90 mainline, the most frequent crash types are rear-end and sideswipe, which accounts for 1,416 of the 2,392 crashes, or 59 percent.

Crashes with a fixed object are the third most common crash type accounting for 708 crashes, or 30 percent of total crashes.

Common poor driving behaviors including exceeding a reasonably safe speed, following too closely, and inattention contributed to 63 percent of crashes on the I-90 mainline.

Figure 21 shows crash severity by different crash types on the I-90 mainline as defined by the first object hit.

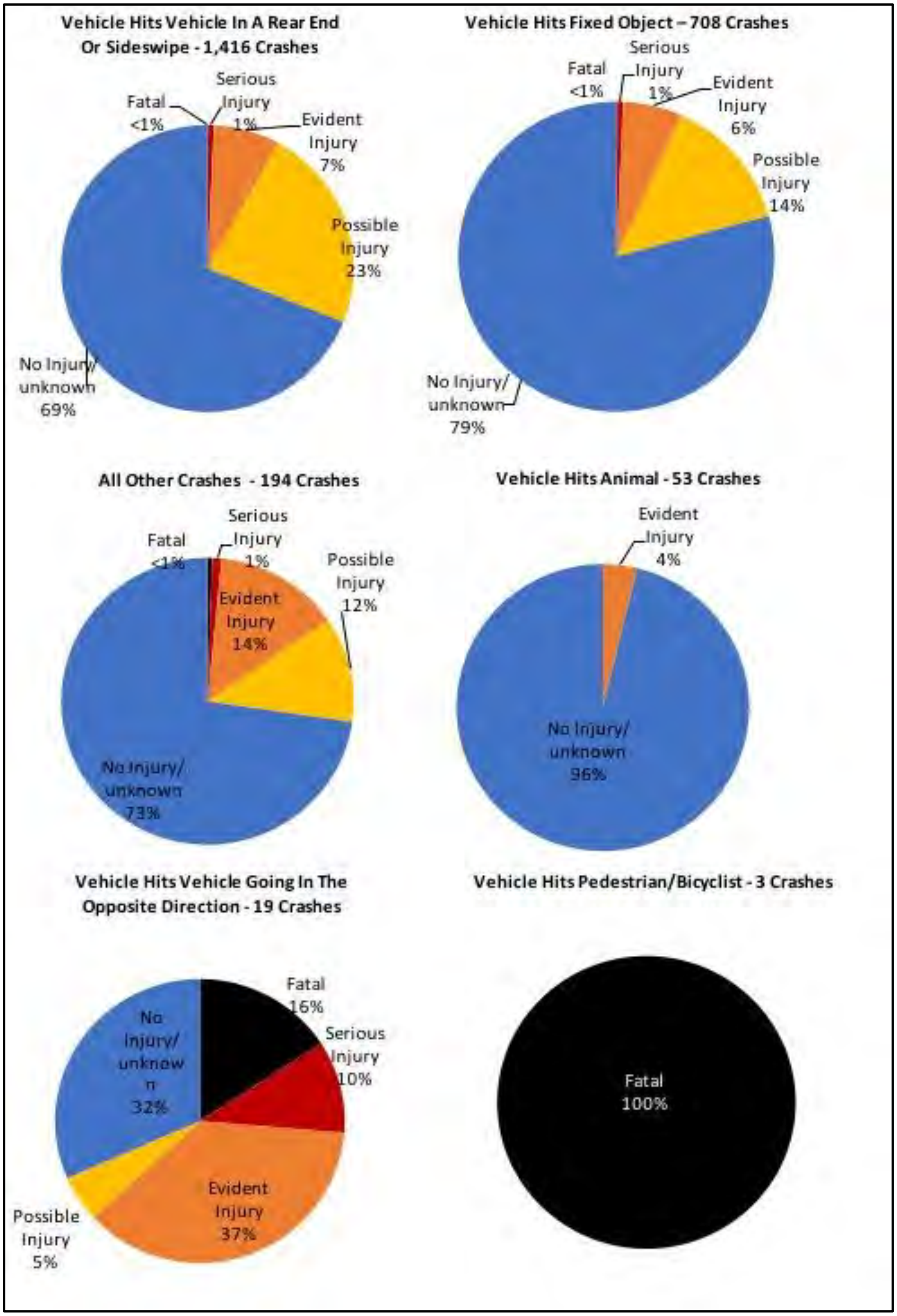


Figure 21: Crash Severity by Type on I-90 Mainline

Crash Frequency and Contributing Factors

Table 5 and Table 6 summarize I-90 crash frequency and contributing factors by segment and travel direction. Table 5 presents the total crashes on I-90 mainline by segment and contributing factors. The three most common contributing factors were: inclement weather, exceeding a reasonably safe speed, and following too closely. Together, these factors contribute to 84 percent of all crashes in the study corridor. Driver inattention is a factor in 15 percent of mainline crashes and heavy-vehicles are involved in 10 percent of mainline crashes.

Table 5: I-90 Mainline Crash Contributing Factors by Segment and Direction

Segment / Direction	Annual Average Daily Traffic	Crash Frequency		Contributing Factors				
		Total Crashes	High Severity Crashes	Exceeding Reasonably Safe Speed	Following too closely	Inattention	Inclement Weather Road Surface	Heavy Vehicle Involved Crashes
Segment A (MP 270– 277)	**30,300**	**251**	**8**	**39%**	**10%**	**8%**	**43%**	**13%**
Eastbound	16,300	135	7	32%	16%	10%	35%	13%
Westbound	14,000	116	1	47%	3%	6%	52%	13%
Segment B (MP 277– 286)	**85,100**	**1272**	**12**	**26%**	**25%**	**17%**	**30%**	**12%**
Eastbound	42,600	671	8	27%	25%	18%	27%	12%
Westbound	42,500	601	3	26%	25%	16%	33%	13%
Segment C (MP 286– 293)	**71,800**	**499**	**2**	**38%**	**10%**	**10%**	**50%**	**7%**
Eastbound	36,000	231	1	37%	9%	11%	45%	7%
Westbound	35,800	268	1	40%	12%	9%	54%	7%
Segment D (MP 293–299)	**53,800**	**371**	**4**	**27%**	**11%**	**17%**	**31%**	**5%**
Eastbound	27,000	228	3	22%	12%	18%	28%	7%
Westbound	26,800	143	1	36%	8%	17%	36%	3%
Study Corridor Total	**62,200**	**2392**	**25**	**30%**	**18%**	**15%**	**36%**	**10%**

Notes: More than one contributing factor can apply to each crash, and not all contributing factors are shown, therefore percentages may not add to 100%.
Bold indicates bidirectional segment value.
Darker red colors indicate higher proportion of contributing factor compared with other study corridor segments.

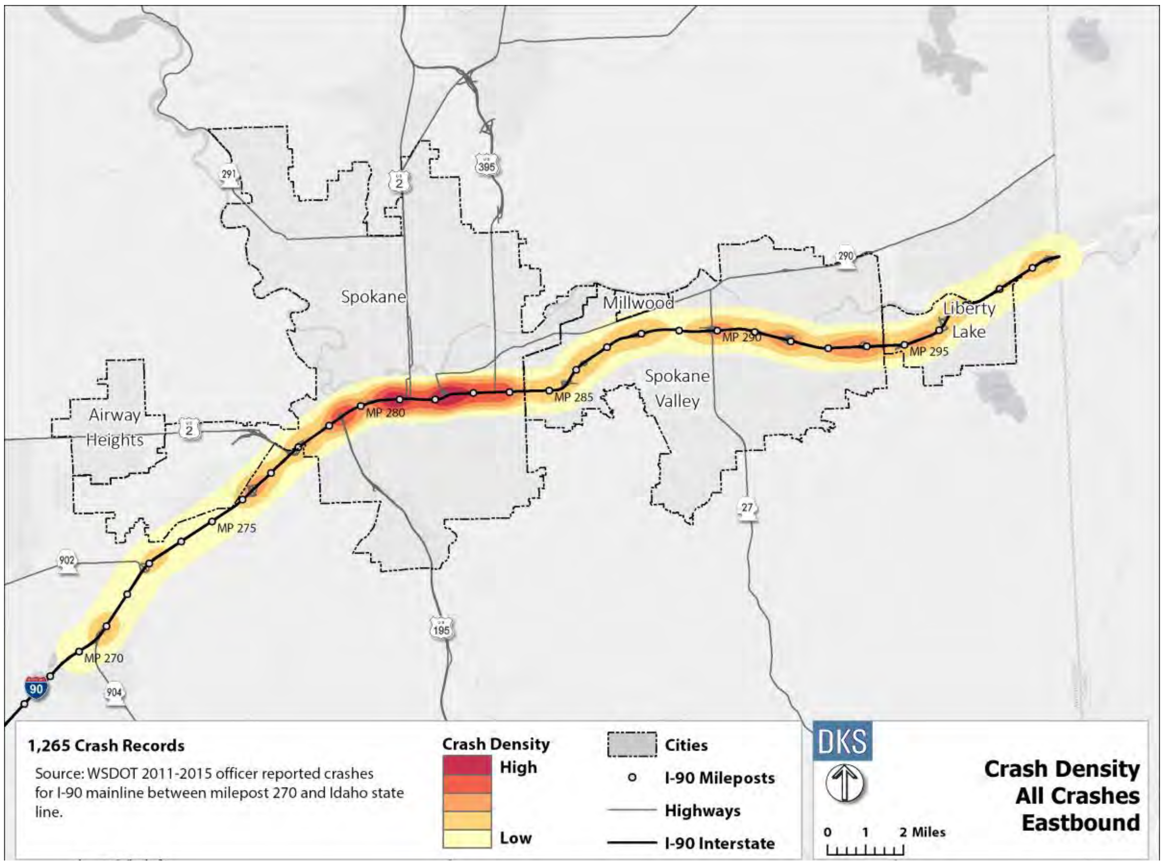
Table 6 presents the crash frequency and contributing factors at each interchange. The table includes crashes that occurred on the ramps or at the intersections at the ramp terminals. As with mainline crashes, the three most common contributing factors were: inclement weather, exceeding a reasonably safe speed, and following too closely. Together, these factors contribute to 57 percent of all crashes at the interchanges.

Table 6: Interchange Crash Frequency and Contributing Factors

Interchange	Crash Frequency		Contributing Factors				
	All Crashes	High Severity Crashes	Exceeding Reasonably Safe Speed	Following Too Closely	In-attention	Inclement Weather Road Surface	Heavy Vehicle Involved Crashes
Exit 270 - SR 904/Four Lakes/Cheney	18	0	44%	6%	17%	44%	0%
Exit 272 - SR 902/Medical Lake	17	0	35%	6%	12%	41%	18%
Exit 276 - Geiger Boulevard/Grove Rd.	8	0	50%	0%	25%	75%	0%
Exit 277 - US 2/Garden Springs Rd.	40	0	55%	3%	3%	45%	5%
Exit 279 - SR 195	55	1	20%	36%	22%	11%	2%
Exit 280 - Maple St./4th Ave/Walnut St.	365	6	7%	26%	15%	18%	5%
Exit 281 - US 2 Browne St. /Division St. Couplet	164	5	13%	12%	13%	23%	5%
Exit 282 - SR 290	47	1	47%	4%	13%	47%	2%
Exit 283A - Altamont St./2nd Ave./3rd Ave.	8	0	13%	25%	25%	25%	0%
Exit 283B - Thor St./Freya St./2nd Ave./3rd Ave.	30	0	10%	20%	17%	13%	17%
Exit 285 - Sprague Ave.	83	1	31%	12%	12%	27%	2%
Exit 286 - Broadway Ave.	45	1	18%	22%	16%	24%	9%
Exit 287 - Argonne Rd.	81	2	11%	14%	16%	22%	4%
Exit 289 - SR 27/Pines Rd.	46	0	13%	22%	15%	13%	0%
Exit 290 - Evergreen Rd.	55	1	25%	20%	7%	22%	2%
Exit 291 - Sullivan Rd.	133	1	11%	11%	11%	28%	7%
Exit 293 - Barker Rd.	36	0	6%	17%	28%	17%	6%
Exit 294 - Sprague Ave./Business Route 90	5	0	20%	0%	20%	0%	0%
Exit 296 - Liberty Lake Rd./Harvard Rd.	58	0	0%	16%	22%	14%	5%
Exit 299 - Idaho Rd./Spokane Bridge Rd.	13	0	31%	8%	8%	23%	0%
Study Corridor Interchanges Total	**1307**	**19**	**16%**	**18%**	**14%**	**23%**	**5%**

I-90 All Crashes Hot Spots

Along the I-90 corridor, safety is a primary concern. As a busy urban corridor, crashes and other incidents along I-90 are frequent occurrences that endanger travelers and contribute to non-recurring congestion and travel time unreliability. The most frequent contributing circumstances include three common driver behaviors: exceeding a reasonably safe speed, following too closely, and inattention. Together, these behaviors are involved in about 60 percent of crashes on the Interstate 90 mainline. Crash density for all eastbound crashes is shown in Figure 22 and crash density for all westbound crashes is shown in Figure 23.



Traveling Eastbound

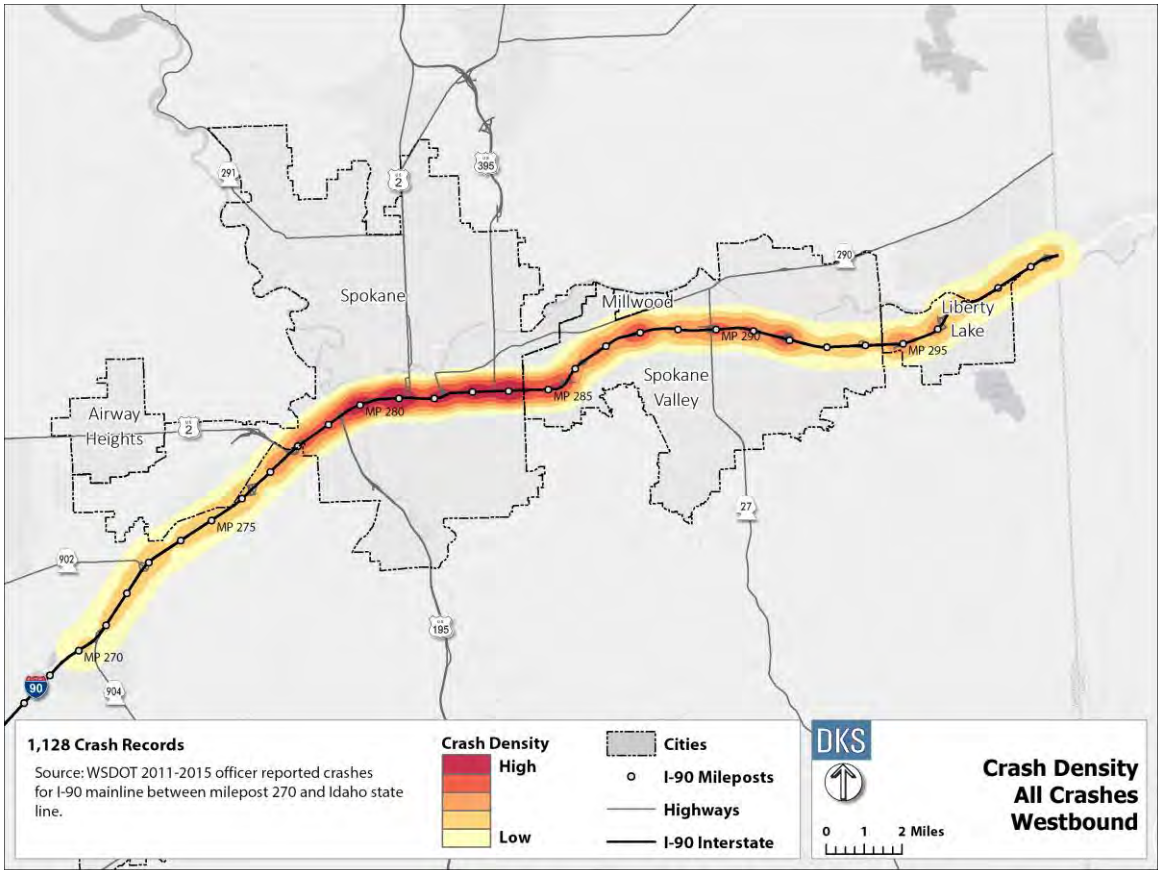
Eastbound crashes are concentrated through downtown Spokane (MP 279 -284). Crashes are strongly clustered in the evening peak period.

Segment B (downtown Spokane) has the highest frequency of crashes (1,271 total, of which 671 are eastbound). Segment B also has the highest crash rate, at 0.91 crashes per million vehicle miles traveled (MVMT).

At 30 percent of all crashes, exceeding a reasonably safe speed is the most common contributing factor to crashes along the mainline study corridor.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 22: I-90 Crash Density - All Crashes Eastbound



Traveling Westbound

Westbound crashes are also concentrated through downtown Spokane (MP 279 -284). Crashes are strongly clustered in the evening peak period.

Segment B (downtown Spokane) has the highest frequency of crashes (1,271 total, of which 600 are westbound). Segment B also has the highest crash rate, at 0.91 crashes per million vehicle miles traveled (MVMT).

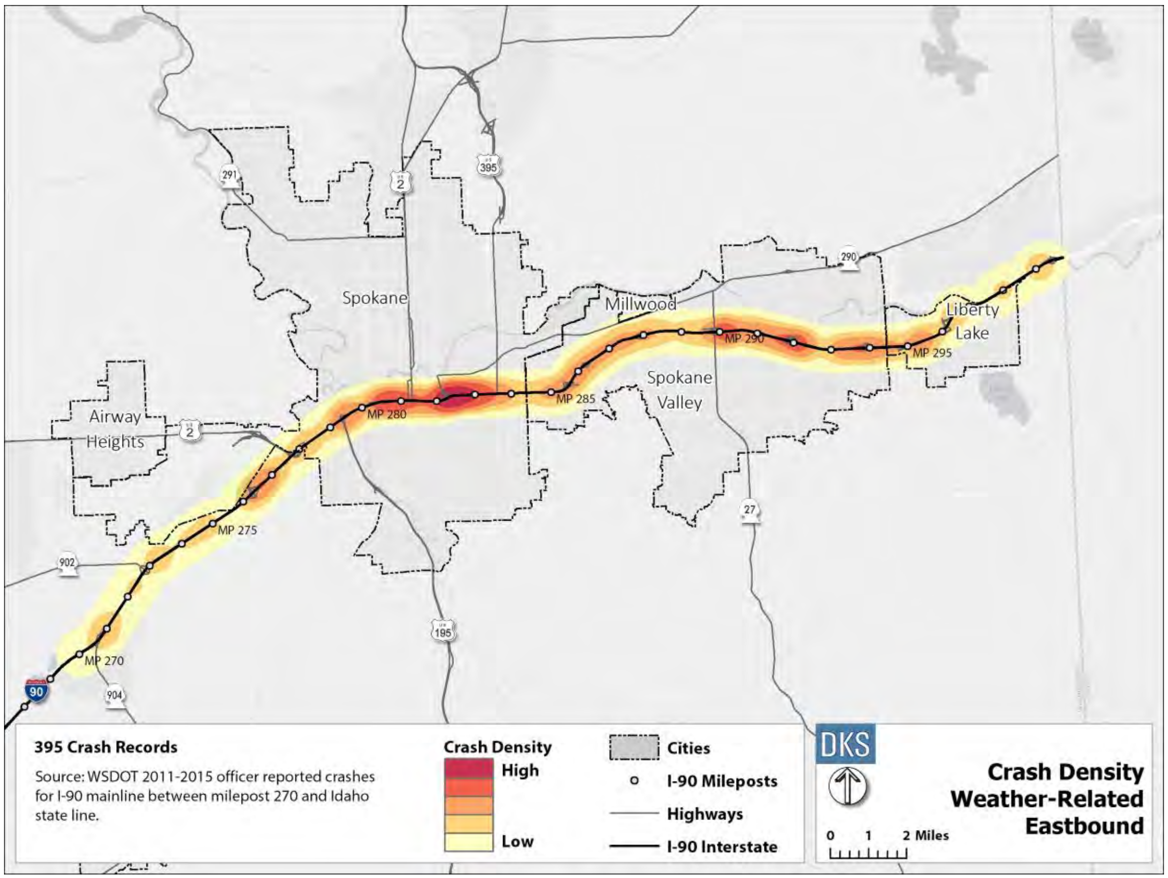
At 30 percent of all crashes, exceeding a reasonably safe speed is the most common contributing factor to crashes along the mainline study corridor.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 23: I-90 Crash Density - All Crashes Westbound

I-90 Weather-Related Crashes Hot Spots

Inclement weather road surfaces – such as ice, snow, or water – were a notable factor in crashes along the I-90 corridor. Although primarily occurring during winter months, inclement weather was involved in 36 percent of mainline crashes. In Spokane Valley, half of all crashes involved inclement weather road surfaces. Weather-related crashes include a higher proportion of a.m., midday, and overnight crashes. Speed is a prominent contributing factor for these crashes. Figure 24 illustrates weather-related eastbound crashes and Figure 25 illustrates all weather-related westbound crashes.



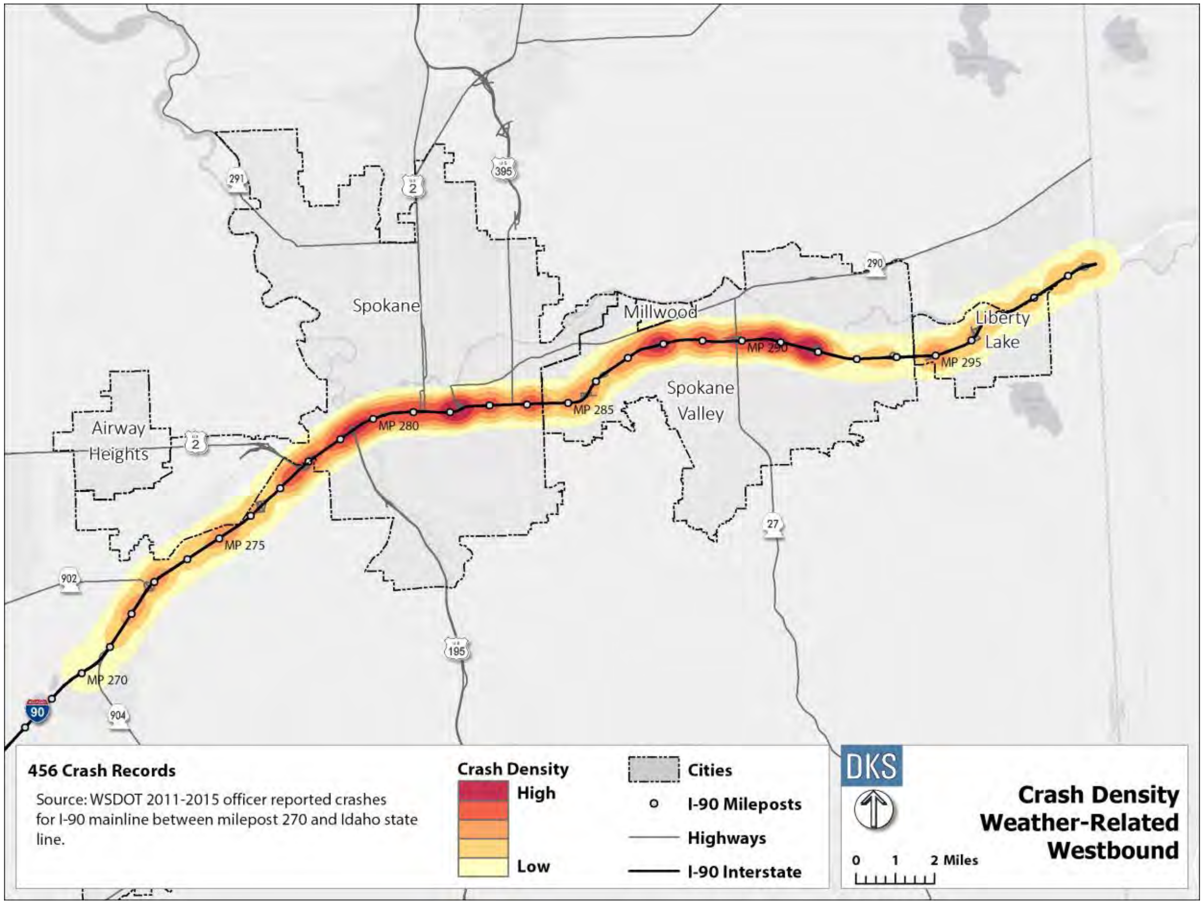
Traveling Eastbound

Weather-related crashes occur almost exclusively between November and February, and include a higher proportion of a.m., midday, and overnight crashes.

More eastbound weather related crashes occur in the downtown Spokane segment than any other segment as shown in the graphic. Each year, approximately 80 eastbound crashes occur during inclement weather on this segment of I-90.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 24: Crash Density - Weather-Related Eastbound Crashes



Traveling Westbound

Weather-related crashes occur almost exclusively between November and February, and include a higher proportion of a.m., midday, and overnight crashes

Westbound weather related crashes are more frequent in the segments through downtown Spokane and Spokane Valley. Each year, nearly 100 westbound crashes occur during inclement weather on this segment of I-90.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 25: Crash Density - Weather-Related Westbound Crashes

I-90 Interchange Ramp and Terminals Crash Hot Spots

More than 1,300 crashes occurred at interchanges and ramp terminals between 2011 and 2015. These 1,300 crashes include crashes on both the ramps and at the ramp intersection terminals. Interchanges are common locations for rear-end and side swipe crashes due to stopped vehicles exiting the Interstate at locations such as Division Street that experiences queuing from the exit ramp traffic signals, and due to vehicles entering the Interstate that often enter in platoons as they depart traffic signals at the entrance ramps. Along the I-90 corridor, three interchanges experience the highest number of crashes as illustrated in Figure 26: Maple St/Walnut St, Division St/Browne St, and Sullivan Rd.

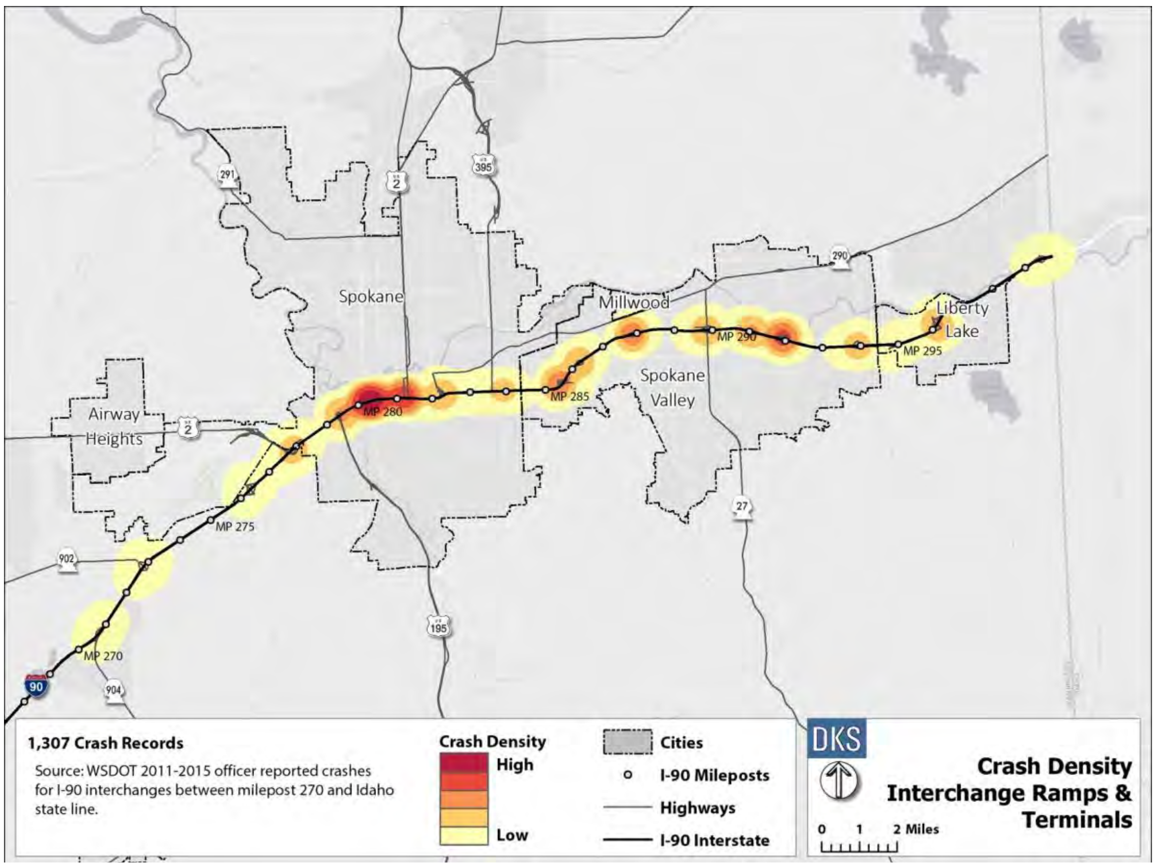


Figure 26: Crash Density - Interchange Ramps and Terminals

Interchange Ramps

As shown in the graphic, the three interchanges with the highest number of crashes include:

- Exit 280 - Maple St/Walnut St
- Exit 281 – Division St/Browne St
- Exit 291 – Sullivan Rd

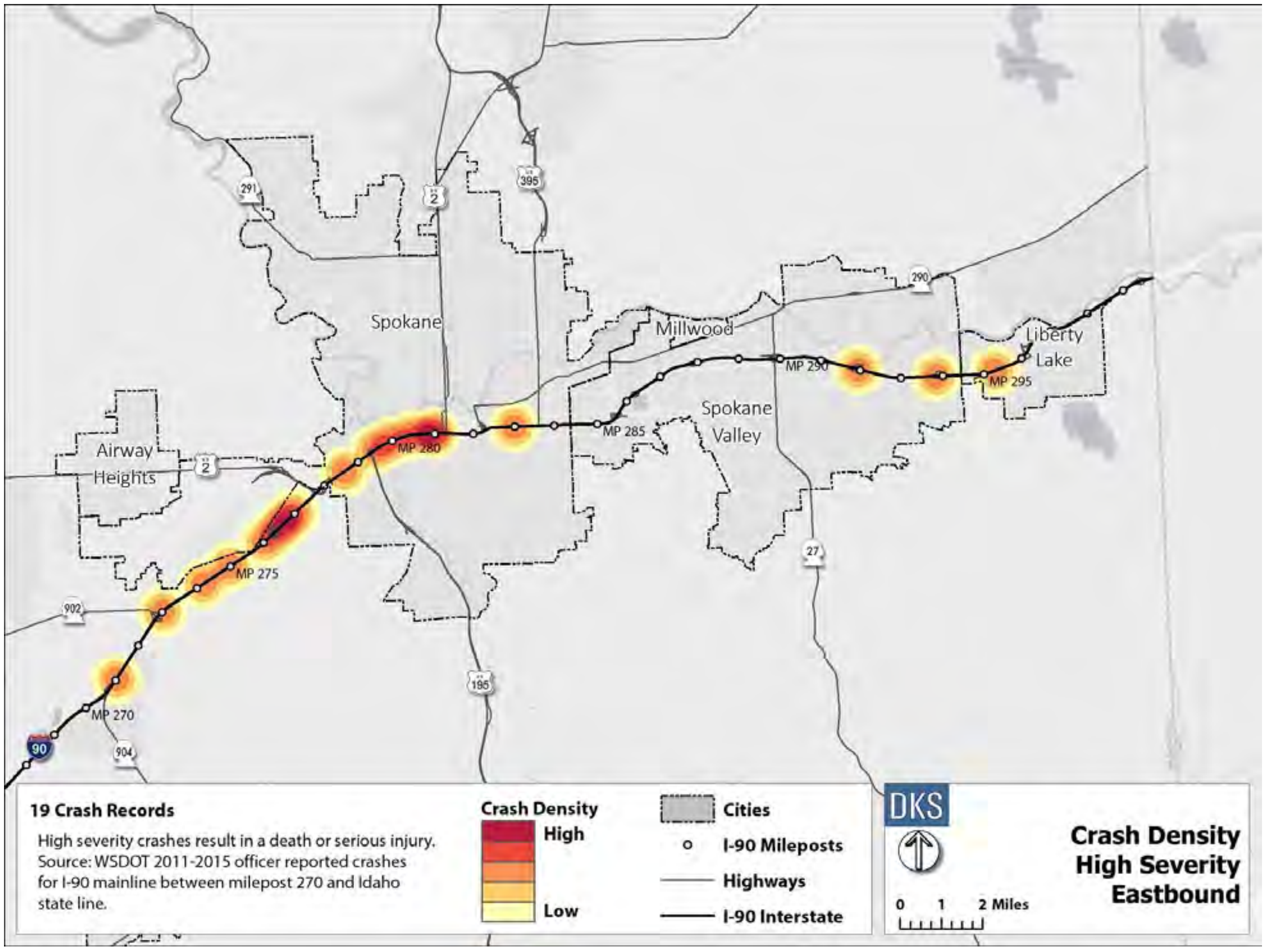
With 365 crashes, or 28 percent of all interchange crashes, exit 280 - Maple Street/Walnut Street is the most crash prone interchange.

Exit 281 – Division St/Browne St, and Exit 291 Sullivan Road each experienced more than 100 crashes each.

Source: WSDOT, officer reported crashes 2011-2015.

I-90 High Severity Crash Hot Spots

High severity crashes include fatal and serious injury collisions, and accounted for 25 of the 2,392 I-90 mainline crashes between 2011 and 2015. The top contributing factor to high severity crashes is driving under the influence, which contributed to nearly 25 percent of all high severity crashes. Figure 27 illustrates high-severity eastbound crashes and Figure 28 illustrates high-severity westbound crashes.



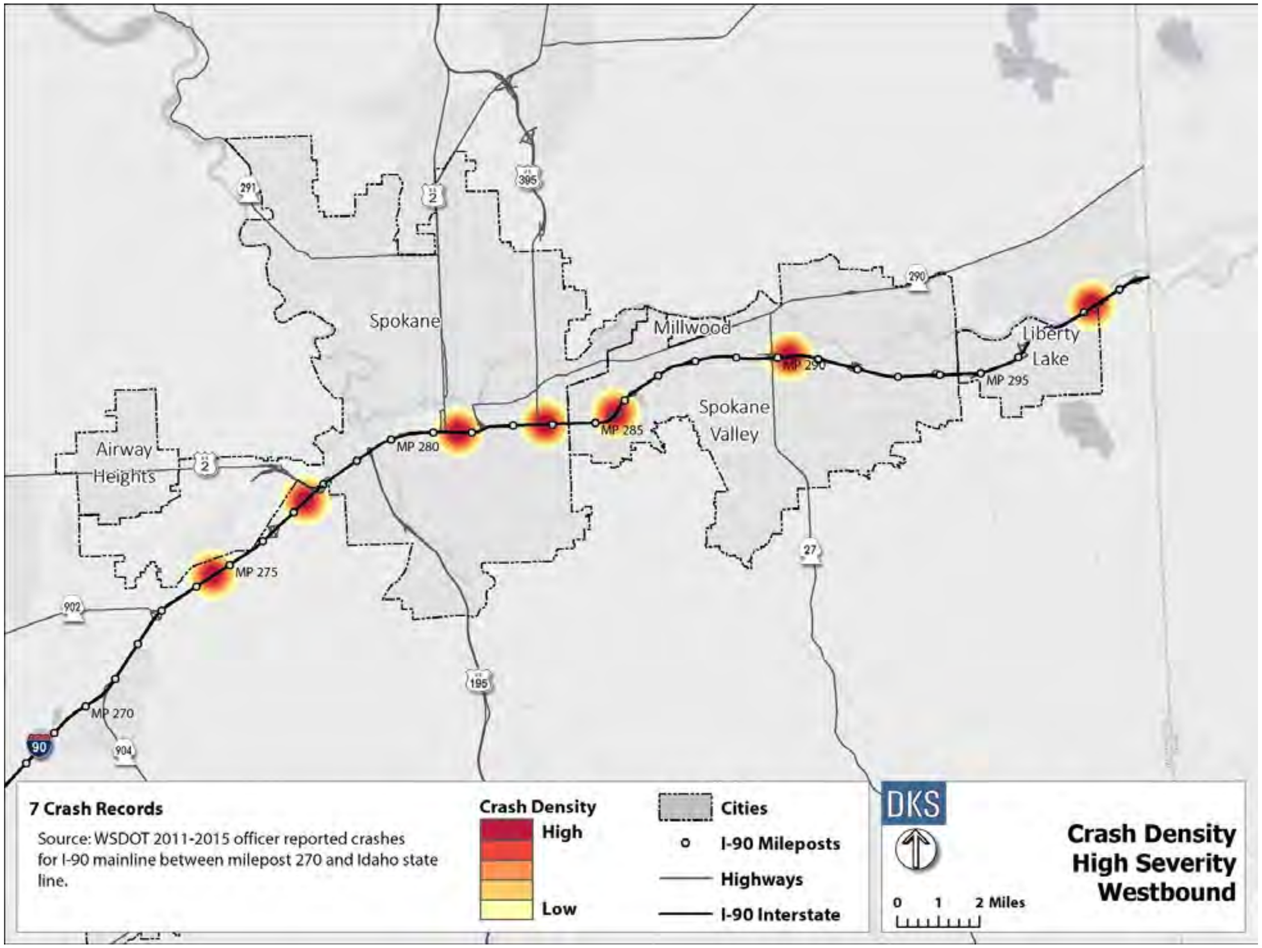
Traveling Eastbound

Segment B (downtown Spokane) has the highest frequency of high severity crashes (12). Segment B also has the highest crash rate, at 0.91 crashes per million vehicle miles traveled (MVMT).

The eastbound direction experienced twice as many high severity crashes than westbound with most occurring west of MP 280.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 27: Crash Density - High Severity Eastbound



Traveling Westbound

Segment B (downtown Spokane) has the highest frequency of high severity crashes (11). Segment B also has the highest crash rate, at 0.91 crashes per million vehicle miles traveled (MVMT).

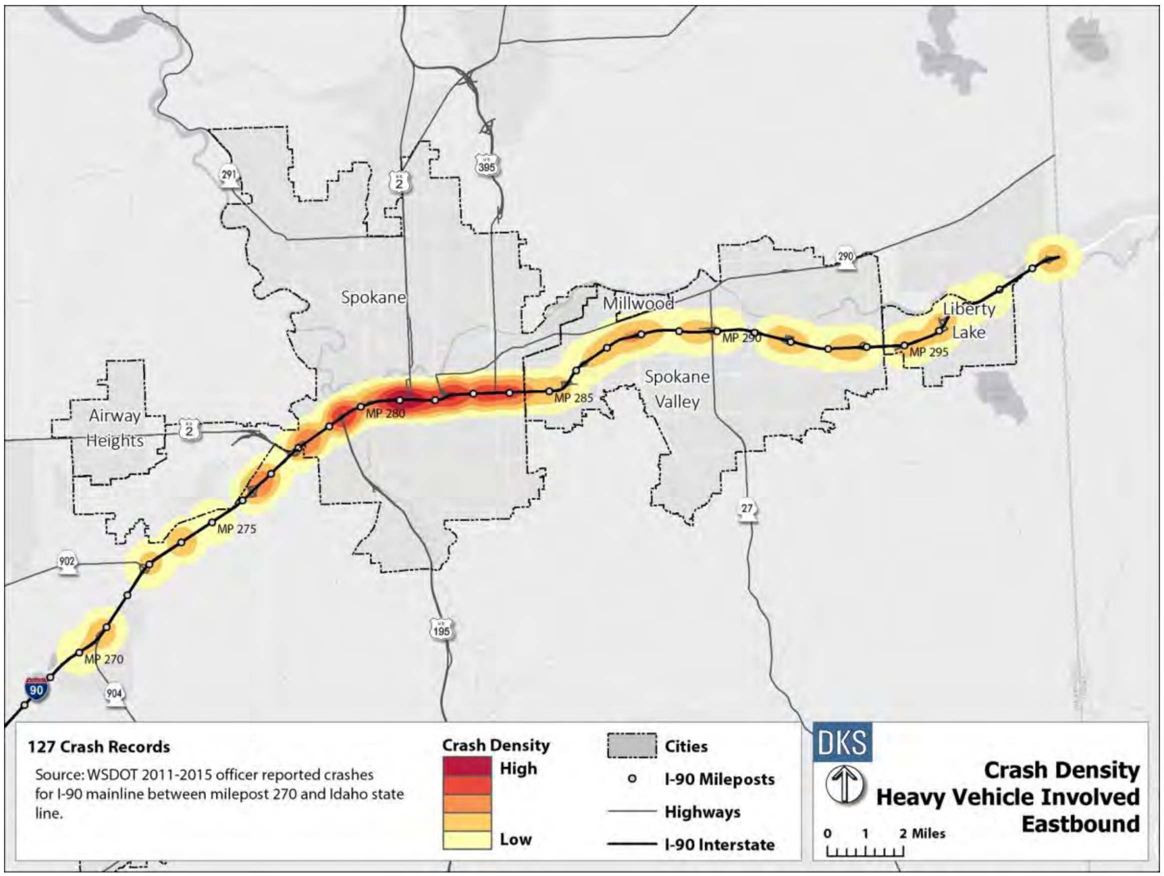
The eastbound direction experienced twice as many high severity crashes than westbound with most occurring west of MP 280.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 28: Crash Density - High Severity Westbound

I-90 Heavy Vehicle Crash Hot Spots

Crashes involving heavy vehicles accounted for 10 percent of the 2,392 crashes on I-90 mainline and five percent of the 1,307 crashes at the interchanges, totalling more than 350 crashes over the five-year period between 2011 and 2015. Three interchanges, Exit 272 SR904 and Exit 283B Freya St, and Exit 286 Broadway, experienced a higher percentage of crashes involving heavy vehicles than other interchanges. At Exit 272 heavy vehicles accounted for 18 percent of the 17 crashes, 17 percent of the 30 crashes at Exit 283B, and 9 percent of the 45 crashes at Exit 286. Figure 29 illustrates eastbound crashes involving heavy vehicles and Figure 30 illustrates westbound crashes involving heavy vehicles.



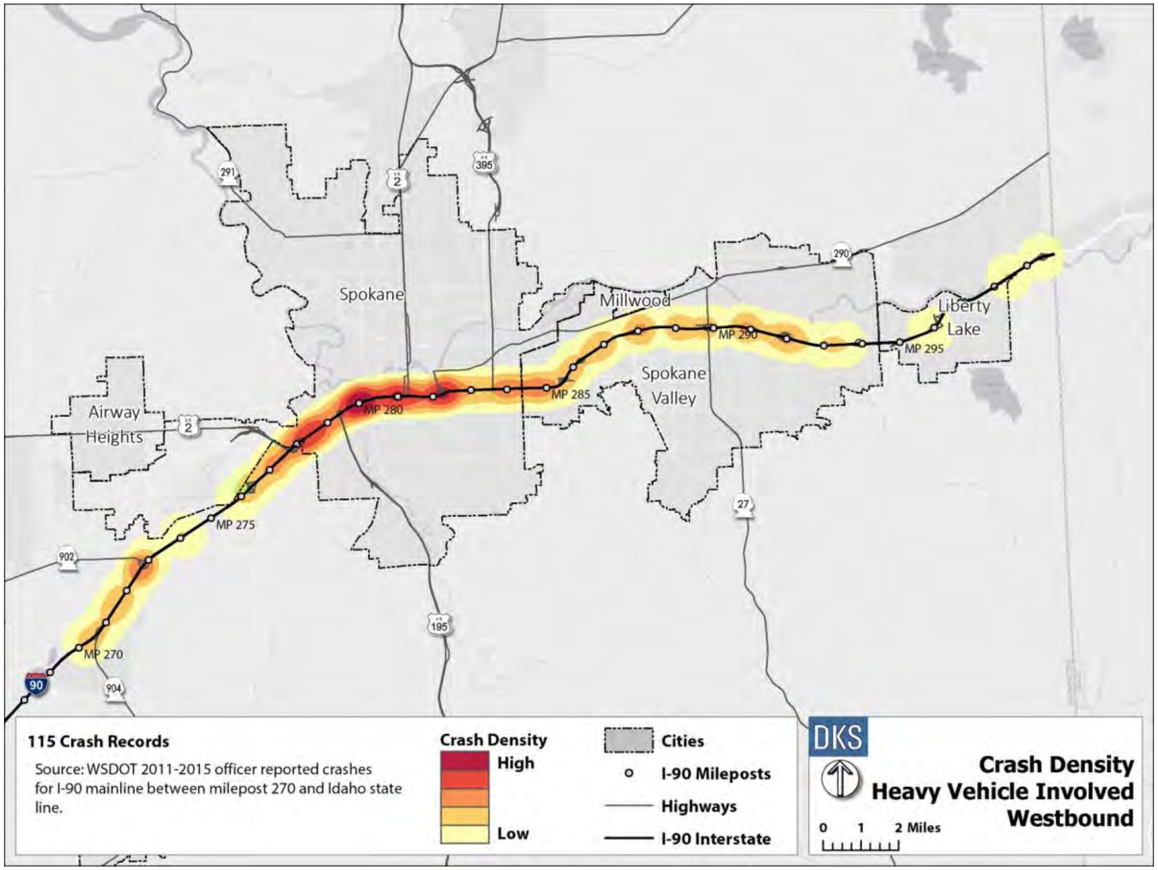
Traveling Eastbound

The majority of crashes involving heavy vehicles occur in the downtown Spokane segment and west between MP 276 and 284, and frequently involve a driver failing to grant right-of-way to a vehicle.

Although segment C has the second highest overall vehicle volumes, it experienced fewer crashes involving heavy vehicles.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 29: Crash Density - Heavy Vehicle Involved Eastbound



Traveling Westbound

The majority of crashes involving heavy vehicles occur in the downtown Spokane segment and west between MP 276 and 284, and frequently involve a driver failing to grant right-of-way to a vehicle.

Although segment C has the second highest overall vehicle volumes, it experienced fewer crashes involving heavy vehicles.

Source: WSDOT, officer reported crashes 2011-2015.

Figure 30: Crash Density - Heavy Vehicle Involved Westbound

Predictive Safety Analysis

A predictive safety analysis helps identify locations with safety performance issues. It can predict the number of fatal and injury crashes based on the relationship between roadway characteristics including roadway geometry, cross section elements, roadside barriers, and safety. The I-90 predictive safety analysis looked at the safety performance of key interchanges, including mainline segments and weaving locations, using the Enhanced Safety Prediction Methodology and Analysis Tool for Freeways and Interchanges (ISATe).[5] One advantage of predictive analysis is that it highlights opportunities for operational countermeasures for implementation. The analysis achieves this by isolating the impacts of geometric and traffic volumes from driver behavior and road conditions (i.e. weather). Review of the individual crash reports provides further insight in the process of selecting countermeasures for further evaluation.

The predictive safety analysis was conducted for two segments: the section of I-90 between US 2 and Broadway interchanges, and for Sullivan interchange. These locations were identified as crash hot spots in the WSDOT crash data evaluation that warranted further analysis. The full ISATe results are included in the appendix.

Methodology

ISATe provides a structured methodology to estimate the expected average crash frequency for a freeway with known characteristics and an available crash history. The project study area is divided into one or more sites, each of which is constant with respect to certain geometric features. Using a spreadsheet tool, the geometric design and traffic characteristics of each site are modeled and used to estimate the safety performance for a typical freeway with similar geometry and traffic volumes. The underlying mathematical functions for ISATe were developed using data from Washington State freeways, and thus does not require local calibration. The actual crash history of the freeway is combined with the model outputs to produce a reliable estimate of the long-term crash frequency for the site, including distributions by severity and type of crash.

- **Observed Crash Frequency** is the number of crashes reported in a specific time period. Each observed crash is assigned to a site, and observed crashes are categorized by severity (fatal-and-injury or property damage only), type (multiple vehicle or single vehicle), and location (freeway segment or ramp entrance/exit area). Due to the random nature of crashes, the observed crash frequency at a specific location often fluctuates over time. An important aspect of the ISATe analysis is that it takes the observed crashes and smooths the data so that abnormal spikes do not compromise the results (see "expected crash frequency" definition below).
- **Predicted Crash Frequency** is the number of crashes forecast for a specific time period by the ISATe model based on geometric design and traffic characteristics. The predicted crash frequency represents a consistent estimate of the "typical" anticipated safety performance for the specific set of conditions modeled. The predicted crash frequency has two main components:

[5] FHWA website, Crash Modification Factors in Practice, http://safety.fhwa.dot.gov/tools/crf/resources/cmfs/alternative.cfm

- **Safety Performance Functions (SPFs)** are formula that model the relationship between traffic volume and crash frequency, for a basic site condition. For instance, there is one SPF for "Urban Six-Lane Divided Freeway Segments" that returns a predicted crash frequency for any traffic volume within the valid range.
- **Crash Modification Factors (CMFs)** are variables that represent the impact of specific geometric designs and traffic characteristics. Initial crash predictions are multiplied by CMFs to obtain a new crash prediction. CMFs greater than one indicate an increase in crash frequency, while CMFs less than one indicate a decrease. The differences between the actual site to be modeled and the basic site condition of the SPF are expressed through CMFs. For instance, a basic site condition might be six-foot wide shoulders while the site to be modeled has twelve-foot wide shoulders. The reduction in crashes predicted by this difference would be represented through a CMF less than one.

- **Expected Crash Frequency** combines the observed crash frequency with the predicted crash frequency using a technique called the Empirical-Bayes Method, described in detail in the HSM. By incorporating the observed crash history, the impacts of non-modeled factors are factored in. Site specific variations that are not modeled include environmental conditions, driver behavior, maintenance conditions, congestion, and the innumerable other details that make each site unique. ***The expected crash frequency is considered to be the most reliable estimate of the long-term safety performance of an actual site under the modeled conditions, and is therefore recommended for use when calculating the potential benefits of implementing safety countermeasures.***
- **Excess Expected Crash Frequency** is defined as the expected crash frequency minus the predicted crash frequency. The comparison of expected crashes to the predicted crashes evaluates a site's performance versus a typical similar site. Positive excess expected values indicate more crashes than a typical similar site, while negative excess expected values indicate less crashes than a typical similar site. Negative values do not necessarily indicate acceptable safety performance, only that safety performance is consistent with the understood impacts of the modeled geometric designs and traffic conditions.
- **Percent Excess Expected** is defined as the excess expected crash frequency divided by the predicted crash frequency. This presents the same analysis as the excess expected crash frequency, but it is normalized in a way that makes it easier to compare sites with varying lengths and traffic volumes. As with excess expected crash frequency, positive values indicate sites that are expected to experience more crashes than typical similar sites, and negative values indicate sites that are expected to experience fewer crashes than typical similar sites.

Analysis and Results for Downtown Segment

This ISATe analysis builds on an initial investigation by WSDOT[6], which looked at the entire length of the downtown section of I-90 as a single site. To better understand the safety issues at specific points in the downtown section of I-90, this analysis disaggregated the data into multiple sites, shown in Figure 31.

[6] Collision Data Analysis, 2015 ER Project Definition Countermeasure Recommendations. I-90/US 2 Garden Springs I/C to Broadway Rd Interchange. WSDOT.

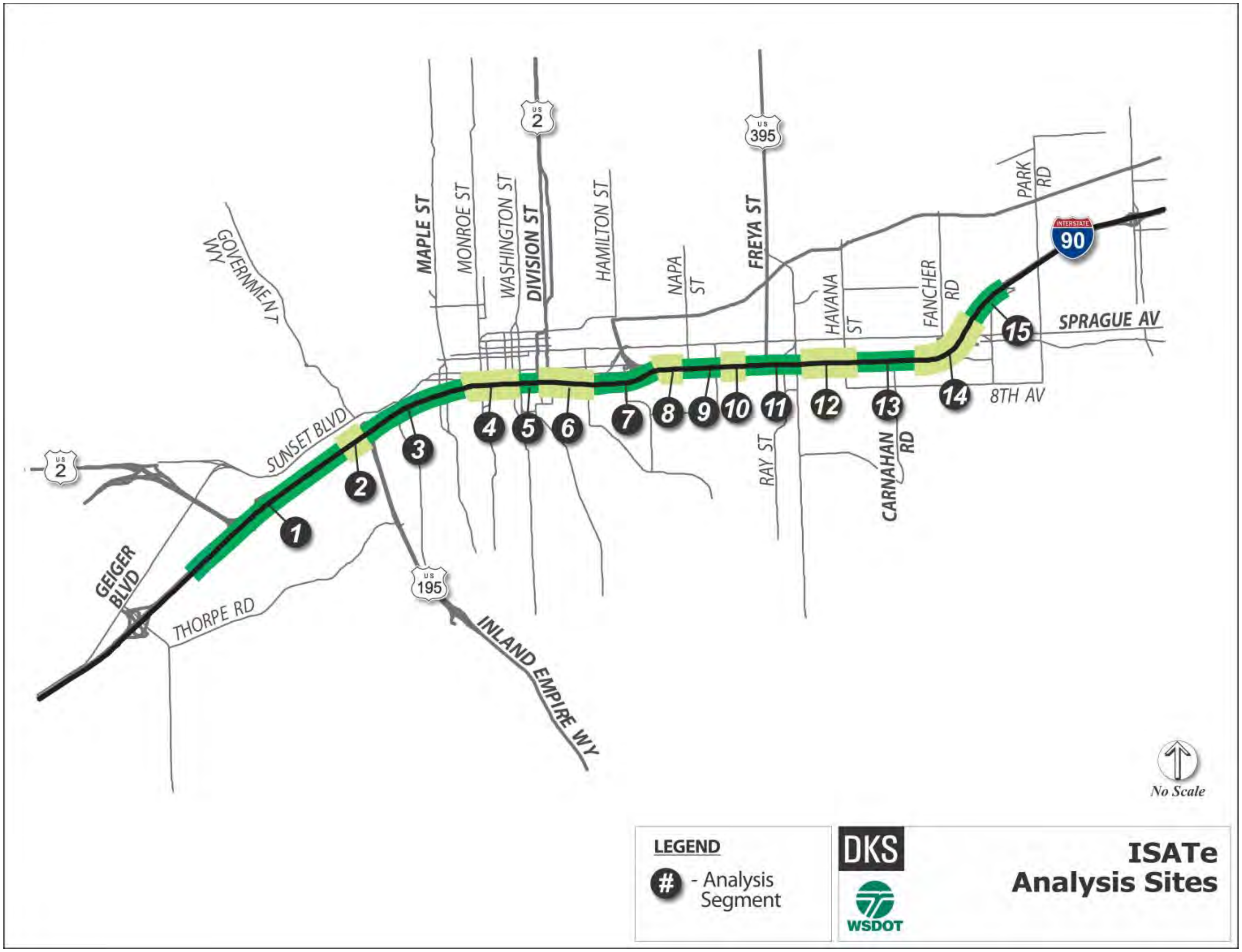


Figure 31: ISATe Analysis Sites for Downtown Segment

The ISATe results for the I-90 mainline through the downtown Spokane area are summarized in Table 7. The analysis found that several of the sites had excess expected crashes, indicating that they experience more crashes than would be expected at a similar site. The areas with excess expected crashes higher than 20 percent include:

- US 195 Interchange area (site 2), with 60% excess expected crashes.
- The section between Monroe and Division (site 4), with 44% excess expected crashes.
- Freya Street Interchange area between ramps (site 11), with 43% excess expected crashes.
- The section between US 195 and Monroe Street (site 3), with 31% excess expected crashes.
- Division Interchange area (site 5), with 20% excess expected crashes.

Five sites had a high percentage of excess expected crashes:

- **US 195 Interchange**
- **I-90: Monroe to Division**
- **Freya Interchange**
- **I-90: US 195 to Monroe**
- **Division Interchange**

For sites that do not show excess expected crashes, the CMFs and SPFs should be considered before determining there are no safety issues at the site. Sometimes the CMFs alone can be an indicator of a safety issue. In this study, sites 6, 8, 10, 12, and 13 do not have positive excess expected crashes; however, these sites have CMFs that indicate crashes are more likely at those locations. The Freya on-ramp (site 12) illustrates this caveat. It has a very short merge area (less than 300 feet). The Freya ramp entrance geometry dictated a high CMF that resulted in a high number of predicted crashes. Relative to other sites, site 12 does have a high expected crash frequency, but not greater than the predicted value at this site due to the site's geometry. Table 7 lists whether a site experienced excess expected crashes and if not, whether there were contributing factors to consider for safety improvements. The full ISATe results are included in Appendix A.

Table 7: ISATe Results - I-90 Through Downtown Spokane

Site No.	Site Description	Included On-Ramps	Site Extents		Site Length (miles)	Are there excess expected crashes? If not, what were the determining factors?	Percent Excess Expected
1	US 2 to US 195	US 2 EB on-ramp	277.74	279.2	1.46	Yes	4%
2	US 195 Interchange	US 195 WB on-ramp US 195 EB on-ramp	279.2	279.55	0.35	Yes	60%
3	195 to Monroe	WB Maple on-ramp EB Walnut on-ramp WB Monroe on-ramp	279.55	280.63	1.08	Yes	31%
4	Monroe to Division	WB on-off ramp aux lane (Browne to Lincoln weave) EB Monroe on-ramp EB aux lane (Monroe to Division)	280.63	281.16	0.53	Yes	44%
5	Division Interchange (between ramps)	None	281.16	281.36	0.2	Yes	20%
6	Division to Conklin	EB Division on-ramp (2 lanes) WB Hamilton on-ramp	281.36	281.96	0.6	No - Note that the model accounts for a high lane change CMF (~1.4 to 1.5) which increases the expected crashes	
7	Hamilton Interchange	None	281.96	282.5	0.54	Yes	8%
8	East of Hamilton	EB on-ramp from Hamilton WB on-ramp from 2nd/Altamont - weave area	282.5	282.75	0.25	No - Note that the model accounts for a high lane change CMF (~1.9 to 2.3) which increases the expected crashes	
9	Napa to Nelson	Portion of EB Altamont on-ramp	282.75	283.29	0.54	Yes	12%

Table 7: ISATe Results - I-90 Through Downtown Spokane continued

Site No.	Site Description	Included On-Ramps	Site Extents		Site Length (miles)	Are there excess expected crashes? If not, what were the determining factors?	Percent Excess Expected
10	Nelson to Haven or Fiske? (Figure 26 needs updated too)	Portion of EB Altamont on-ramp WB weave (aux lane) between Freya on-ramp and Exit 283A (2nd/Altamont) EB weave (aux lane) between Altamont on-ramp and Freya off-ramp	283.29	283.46	0.17	No - Note that the model accounts for a high lane change CMF (~1.6) which increases the expected crashes	
11	Freya Interchange (between ramps)	None	283.46	284.05	0.59	Yes	43%
12	East of Freya Interchange	EB Freya on-ramp Beginning portion of EB Havana on-ramp	284.05	284.59	0.54	No - Note that the model accounts for a high ramp entrance CMF (~1.8) which increases the expected crashes	
13	Custer to Koren	Main portion of EB Havana on-ramp WB on-ramp from Fancher and Sprague	284.59	285.16	0.57	No - Note that the model accounts for a moderate lane change CMF (~1.2 to 1.3) which increases the expected crashes	
14	Fancher/Sprague Interchange	WB Broadway on-ramp	285.16	285.91	0.75	No	
15	Nixon to Broadway	None	285.91	286.24	0.33	No	

Figure 32 provides a breakdown of the observed crash types at each analysis site in the downtown Spokane segment. A high percentage of the crash types in the downtown Spokane are rear-end crashes. This finding correlates with the ISATe findings for sites with high excess expected crashes.

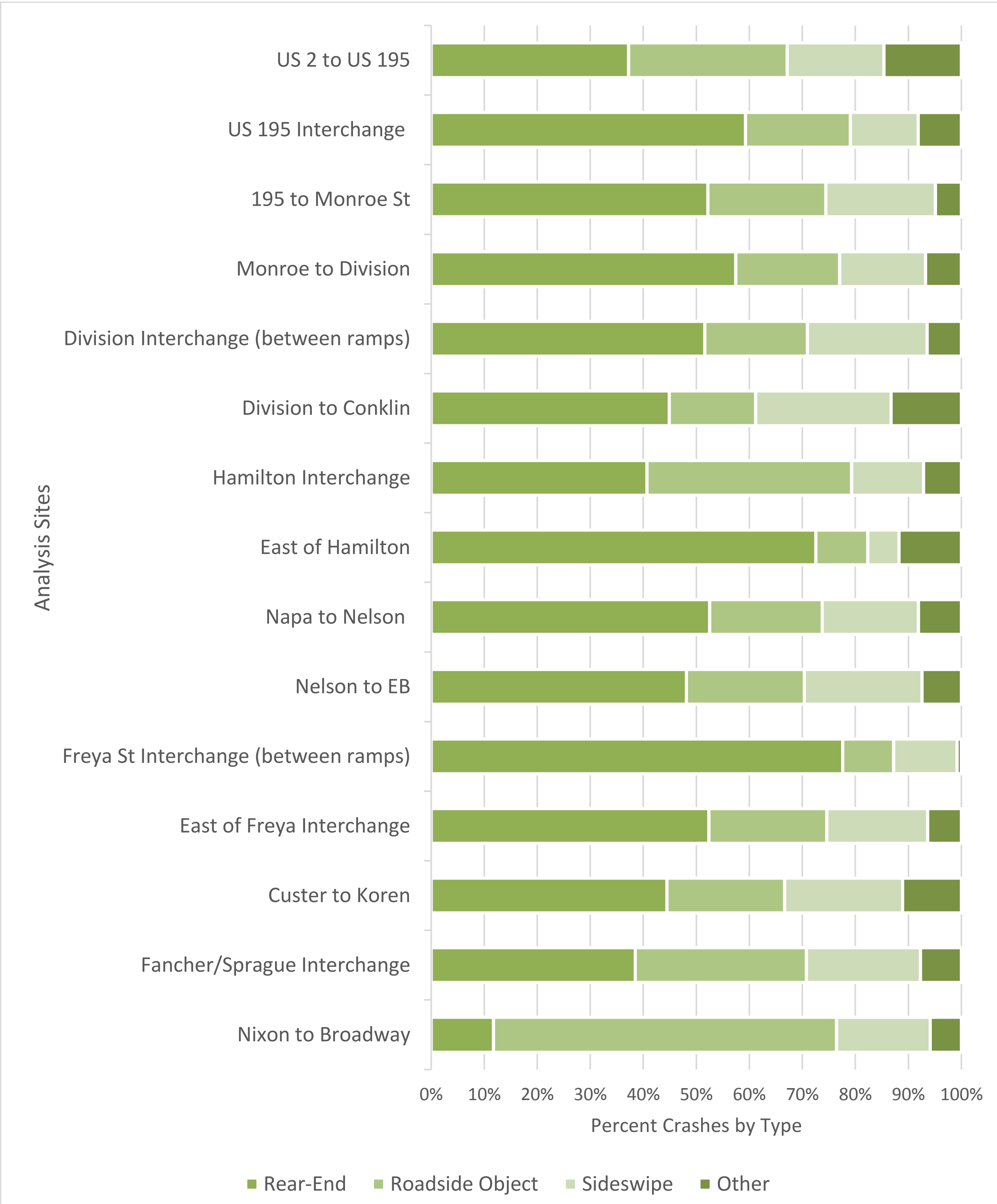


Figure 32: Observed Crash Type Proportions at Downtown Predictive Analysis Sites

Analysis and Results for Sullivan Interchange

An ISATe analysis was also completed for the Sullivan Road interchange that lies outside of the downtown segment. This location was identified as a crash hotspot in the WSDOT crash history analysis. The Sullivan Road interchange was divided into seven analysis sites as shown in Figure 33.

Site 4 was the only site with excess expected crashes, which includes the westbound on-ramp from Sullivan Road. As shown in Figure 33, the westbound on-ramp has a tight radius and a merge area less than 500 feet long, which likely contribute to safety issues. With this level of detail, the results can indicate very specific parts of the roadway to target safety improvements.

Figure 33: Sullivan Road Interchange Analysis Sites

PLANNED AND FUNDED PROJECTS

Several systems and infrastructure projects are funded or planned for the I-90 corridor. These projects may affect how the corridor operates as they are implemented over the next 20 years. Planning for operations on the corridor should account for these projects, which are documented in this section. Projects summarized here include:

- ITS projects
- The North Spokane Corridor
- Additional regional infrastructure projects along I-90

WSDOT and the Idaho Transportation Department (ITD) have implemented ITS strategies for improving system operations in the I-90 corridor. Both agencies adopted ITS plans in 2007 to establishes policies and guide development and investment:

- *WSDOT Eastern Washington ITS Implementation Plan*, 2007[7]
- *Idaho Transportation Department (ITD) I-90 Corridor ITS Strategic Plan*, 2007

In 2013, the Spokane Regional Transportation Management Center (SRTMC) completed the *Spokane Region ITS Systems Plan*[8], working with WSDOT, SRTC, the cities of Spokane and Spokane Valley, Spokane County, and Spokane Transit Authority. The *Spokane Region ITS Plan* took into consideration both the WSDOT and ITD plans for the section of I-90 within the study corridor. Overall, the *Spokane Region ITS Plan* provides strategies to improve system operations by relieving congestion, enhancing safety, providing services to travelers, and assisting transportation system operators in implementing suitable traffic management strategies. It focuses on increasing the efficiency of existing transportation infrastructure, which enhances the overall system performance and reduces the need to add capacity by adding travel lanes through roadway widening.

Recommended projects from the *Spokane Region ITS Plan* are shown in the Planned and Funded Projects section of this memorandum.

ITS Projects

The 2013 Spokane Region ITS Plan laid a vision, supporting goals, and key projects for several TSMO service areas. Projects that are funded or in progress are shown in Table 8.

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[7] http://www.srtc.org/Documents/Documents-Maps/Other_documents/er_final_its_implementation_plan_mar2007.pdf
[8] http://www.srtc.org/Documents/Documents-Maps/Other_documents/Spokane_Region_ITS_Systems_Plan_2013.pdf

Table 8: Spokane Region ITS Plan Projects

Project	Lead Agency	Elements	Priority Ranking	Project Cost (2013 $)	Status
WSDOT F: CCTV Upgrades	WSDOT	Upgrade CCTV cameras on I-90 between US 2 and Argonne Rd) and associated equipment and communications.	Medium	$480,000	Complete
WSDOT-G: I-90 Ramp and Arterials Counters	WSDOT	Install traffic sensors on I-90 ramps and adjacent arterial roadways to support planning, operations, and traveler information.	High	$960,000	Scoping
SR-10: SRTMC Equipment Maintenance and Infrastructure Upgrades	SRTMC	Support ongoing hardware and software maintenance of SRTMC systems. Continuous cost that needs to be secured every biennium.	High	$2,000,000	Current open work order.
SR-13A: Advanced Transportation Management System Upgrade	SRTMC	Upgrade supports CCTV camera control, dynamic message sign control, highway advisory radio control, traffic data station monitoring, weather station monitoring and forecasting, traveler information.	High	Phase 1- $1,790,000	Underway, scheduled completion August 2017
SR-13B: Advanced Transportation Management System Upgrade	SRTMC	Upgrade supports ramp metering, variable speed limit control, regional snow plow activity map, ROADS system interface, travel time estimates	High	Phase 2- $1,000,000	Will be completed in conjunction with 13A

Project	Lead Agency	Elements	Priority Ranking	Project Cost (2013 $)	Status
STA-15: Real-time Park and Ride Traveler Information	STA	Provide travelers with real time information about park and ride lot occupancy.	Low	$500,000	Recently installed at Jefferson and Mirabeau Park and Rides
STA: Liberty Lakes Service	STA	Expanding service to the 174 Liberty Lake Express		Not provided	Sept 2017
STA: New Transit Center	STA	West Plains Transit Center		Not provided	Construction begin in 2017

North Spokane Corridor

Figure 34: North Spokane Corridor Conceptual Alignment and Current Status

The North Spokane Corridor (NSC) is a planned 10.5-mile limited access north-south corridor that will link I-90 at the south end with US 2 and US 395 to the north. Figure 34 shows the planned alignment of the corridor, which is being funded and constructed in phases.

The north segment, between E Francis Avenue and US 395 to the north, is complete. Additional segments and a new interface at I-90 are planned in the region's Metropolitan Transportation Plan, discussed in the next section. The NSC is fully funded for construction to I-90, and is estimated to be complete in 2027.

Continued development of the NSC and ultimately connecting this new major north-south facility to I-90 will likely have a future impact on I-90 operations. The conceptual connection to I-90 is shown in Figure 35.

Figure 35: NSC Conceptual I-90 Connection

Other Planned and Funded Projects

Several projects in the study corridor have been identified in SRTC's financially constrained Metropolitan Transportation Plan (MTP)[9]. Some of the projects in the MTP have either already been constructed or are underway. Table 9 shows projects, cost estimates, planned timeframe, and whether the projects are complete or in progress.

Table 9: SRTC Metropolitan Transportation Plan Projects

MTP Project ID	Project	Description	Project Cost (2011 $)	Status
Short-term projects (2011-2015)				
4	I-90 – Sullivan Interchange to Barker Road	Construct general purpose lanes	$19,000,000	Complete
21	I-90 – Barker Road Interchange	Construct general purpose lanes and replace Barker interchange	$26,500,000	Planned
Medium-term projects (2016-2025)				
8	I-90 Freya westbound off-ramp	Ramp modifications	$3,000,000	Complete
13	I-90 – Barker Interchange to Harvard Interchange	Construct general purpose lanes	$32,000,000	Planned
18	I-90 – Henry Road Interchange	Replace Green Acres Interchange with one at Henry Road	$26,500,000	Planned
22	North Spokane Corridor – I-90 North Access Connection Phase 1	Construct interchange and roadway for half of facility	$190,000,000	Planned
23	North Spokane Corridor – Collector Distributor System Phase 1	Reconstruct I-90 with C-D System Phase 1	$82,000,000	Planned
Long-term projects (2026-2035)				
2	North Spokane Corridor – I-90 North Access Connection Phase 2	Construct interchange and roadway for half of facility	$187,000,000	Planned
4	I-90 Medical Lake Interchange	Interchange modifications	$7,500,000	Planned
5	North Spokane Corridor – Collector Distributor System Phase 2	Reconstruct I-90 with C-D System Phase 2	$230,000,000	Planned
21	I-90 – Harvard Interchange to Idaho State Line	Construct general purpose lanes and structures	$115,000,000	Planned

Source: SRTC Spokane 2011-2035 Metropolitan Transportation Plan

[9] Spokane Regional Transportation Council, Horizon 2040 Metropolitan Transportation Plan for the Spokane Metropolitan Planning Area, 2013, http://www.srtc.org/mtp_2040.html

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APPENDIX A: ISATE RESULTS

DRAFT -- ISATe Summary for I-90 SRMP 277.74 to 286.24

Crash terminology for predictive analysis (Highway Safety Manual)

Observed crash frequency:	The number of crashes recorded in the actual empirical crash data (2011-2015)
Predicted crash frequency:	The number of crashes predicted by the HSM model, without considering actual empirical crash data.
Expected crash frequency	The number of crashes that is likely in the long-run, considering both model predictions and empirical crash data (using Empirical-Bayes method)
Excess Expected crash frequency:	The difference between the predicted crash frequency and the expected crash frequency.

**** Positive values of Excess Expected Crash Frequency are highlighted and indicate ISATe expects higher crash frequencies (in the long run) at the site vs. the model predictions (the baseline).***

EE% here defined as (Excess Expected / Predicted), or "Excess Expected crash frequency as a percentage of Predicted crash frequency

		5-year Total Values				
		Fatal-and-Injury	Property Damage Only	Crash Total	Length (r	Per Mile
Site 1 Crashes	Observed	37.0	97.0	134.0	1.46	91.8
US2 to US195	Predicted	39.5	90.4	129.9	1.46	89.0
includes EB on ramp from US 2	Expected	40.7	94.6	135.3	1.46	92.7
	Excess Expected	**1.2**	**4.2**	**5.4**	**1.46**	**3.7**
	EE%	**3%**	**5%**	**4%**	**100%**	**4%**
Site 2 Crashes	Observed	32.0	53.0	85.0	0.35	242.9
195 Interchange	Predicted	12.8	28.8	41.5	0.35	118.7
includes all 195 ramps	Expected	22.7	43.7	66.4	0.35	189.7
	Excess Expected	**10.0**	**14.9**	**24.9**	**0.35**	**71.0**
	EE%	**78%**	**52%**	**60%**	**100%**	**60%**
Site 3 Crashes	Observed	47.0	137.0	184.0	1.08	170.4
195 to Monroe St	Predicted	37.8	83.9	121.7	1.08	112.7
	Expected	42.6	116.2	158.9	1.08	147.1
	Excess Expected	**4.8**	**32.3**	**37.2**	**1.08**	**34.4**
	EE%	**13%**	**39%**	**31%**	**100%**	**31%**
Site 4 Crashes	Observed	54.0	94.0	148.0	0.53	279.2
Monroe to Division	Predicted	31.1	62.6	93.7	0.53	176.8
includes WB on-off ramp aux lane	Expected	47.2	87.9	135.2	0.53	255.1
	Excess Expected	**16.2**	**25.3**	**41.5**	**0.53**	**78.3**
	EE%	**52%**	**40%**	**44%**	**100%**	**44%**
Site 5 Crashes	Observed	4.0	27.0	31.0	0.2	155.0
Division Interchange	Predicted	7.9	17.1	25.0	0.2	125.2
	Expected	6.3	23.8	30.1	0.2	150.6
	Excess Expected	**-1.6**	**6.7**	**5.1**	**0.2**	**25.4**
	EE%	**-20%**	**39%**	**20%**	**100%**	**20%**
Site 6 Crashes	Observed	30.0	68.0	98.0	0.6	163.3
Division to Garfield	Predicted	34.2	73.1	107.3	0.6	178.9
Includes EB on-ramp	Expected	32.7	70.0	102.7	0.6	171.2
	Excess Expected	**-1.5**	**-3.1**	**-4.6**	**0.6**	**-7.7**
	EE%	**-4%**	**-4%**	**-4%**	**100%**	**-4%**
Site 7 Crashes	Observed	36.0	104.0	140.0	0.54	259.3
Hamilton Interchange	Predicted	33.4	79.8	113.2	0.54	209.6
	Expected	35.9	97.6	133.5	0.54	247.2
	Excess Expected	**2.5**	**17.8**	**20.3**	**0.54**	**37.6**
	EE%	**8%**	**22%**	**18%**	**100%**	**18%**
Site 8 Crashes	Observed	11.0	40.0	51.0	0.24	212.5
includes EB on ramp from Hamilton	Predicted	22.3	45.6	67.9	0.24	282.8
include WB on ramp from 2nd - weave area	Expected	14.3	41.0	55.3	0.24	230.4
	Excess Expected	**-8.0**	**-4.6**	**-12.6**	**0.24**	**-52.4**
	EE%	**-36%**	**-10%**	**-19%**	**100%**	**-19%**
Site 9 Crashes	Observed	23.0	76.0	99.0	0.54	183.3
Napa to Nelson (no ramps?)	Predicted	26.9	61.5	88.4	0.54	163.6
	Expected	26.1	73.1	99.2	0.54	183.7
	Excess Expected	**-0.8**	**11.6**	**10.9**	**0.54**	**20.1**
	EE%	**-3%**	**19%**	**12%**	**100%**	**12%**
Site 10 Crashes	Observed	6.0	21.0	27.0	0.17	158.8
WB weave to Exit 283A (2nd/Altamont)	Predicted	12.7	29.2	41.9	0.17	246.3
EB weave to Exit 283 B (Freya)	Expected	8.7	21.7	30.4	0.17	178.8
	Excess Expected	**-4.0**	**-7.5**	**-11.5**	**0.17**	**-67.5**
	EE%	**-31%**	**-26%**	**-27%**	**100%**	**-27%**
Site 11 Crashes	Observed	32.0	93.0	125.0	0.59	211.9
Freya St Interchange (between ramps)	Predicted	25.5	57.2	82.8	0.59	140.3
	Expected	32.1	85.9	118.0	0.59	199.9
	Excess Expected	**6.5**	**28.7**	**35.2**	**0.59**	**59.6**
	EE%	**26%**	**50%**	**43%**	**100%**	**43%**
Site 12 Crashes	Observed	15.0	48.0	63.0	0.54	116.7
EB Freya on-ramp	Predicted	30.6	68.9	99.5	0.54	184.3
	Expected	21.2	52.9	74.0	0.54	137.1
	Excess Expected	**-9.5**	**-16.0**	**-25.5**	**0.54**	**-47.2**
	EE%	**-31%**	**-23%**	**-26%**	**100%**	**-26%**
Site 13 Crashes	Observed	20.0	34.0	54.0	0.57	94.7
Custer to Koren	Predicted	35.1	79.0	114.1	0.57	200.2
WB on-ramp from Fancher	Expected	25.5	43.8	69.2	0.57	121.5
	Excess Expected	**-9.7**	**-35.2**	**-44.9**	**0.57**	**-78.7**
	EE%	**-27%**	**-45%**	**-39%**	**100%**	**-39%**

DRAFT -- ISATe Summary for I-90 SRMP 277.74 to 286.24

Crash terminology for predictive analysis (Highway Safety Manual)

Observed crash frequency:	The number of crashes recorded in the actual empirical crash data (2011-2015)
Predicted crash frequency:	The number of crashes predicted by the HSM model, without considering actual empirical crash data.
Expected crash frequency	The number of crashes that is likely in the long-run, considering both model predictions and empirical crash data (using Empirical-Bayes method)
Excess Expected crash frequency:	The difference between the predicted crash frequency and the expected crash frequency.

**** Positive values of Excess Expected Crash Frequency are highlighted and indicate ISATe expects higher crash frequencies (in the long run) at the site vs. the model predictions (the baseline).***

EE% here defined as (Excess Expected / Predicted), or "Excess Expected crash frequency as a percentage of Predicted crash frequency

		5-year Total Values				
		Fatal-and-Injury	**Property Damage Only**	**Crash Total**	**Length (**	**Per Mile**
Site 14 Crashes	Observed	16.0	49.0	65.0	0.75	86.7
Fancher/Sprague Interchange	Predicted	34.5	78.1	112.6	0.75	150.1
	Expected	25.6	56.7	82.3	0.75	109.8
	Excess Expected	**-8.9**	**-21.4**	**-30.3**	**0.75**	**-40.3**
	EE%	**-26%**	**-27%**	**-27%**	**100%**	**-27%**
Site 15 Crashes	Observed	6.0	11.0	17.0	0.33	51.5
Nixon to Broadway	Predicted	14.7	33.4	48.2	0.33	145.9
WB on ramp	Expected	9.6	16.8	26.4	0.33	80.0
	Excess Expected	**-5.1**	**-16.6**	**-21.7**	**0.33**	**-65.9**
	EE%	**-35%**	**-50%**	**-45%**	**100%**	**-45%**
Project Total Crashes	Observed	369.0	952.0	1321.0	8.49	155.6
	Predicted	399.0	888.7	1287.7	8.49	151.7
	Expected	391.2	925.7	1317.0	8.49	155.1
	Excess Expected	**-7.7**	**37.0**	**29.3**	**8.49**	**3.4**
	EE%	**-2%**	**4%**	**2%**	**100%**	**2%**

Exit 291 - Sullivan Road

Crash terminology for predictive analysis (Highway Safety Manual)

Observed crash frequency:	The number of crashes recorded in the actual empirical crash data (2011-2015)
Predicted crash frequency:	The number of crashes predicted by the HSM model, without considering actual empirical crash data.
Expected crash frequency	The number of crashes that is likely in the long-run, considering both model predictions and empirical crash data (using Empirical-Bayes method)
Excess Expected crash frequency:	The difference between the predicted crash frequency and the expected crash frequency.

**** Positive values of Excess Expected Crash Frequency are highlighted and indicate ISATe expects higher crash frequencies (in the long run) at the site vs. the model predictions (the baseline).***

EE% here defined as (Excess Expected / Predicted), or "Excess Expected crash frequency as a percentage of Predicted crash frequency

		Fatal-and-Injury	Property Damage Only	Crash Total
Site 1 Crashes	Observed	4.0	12.0	16.0
0.14 mi	Predicted	6.8	13.9	20.7
	Expected	5.1	11.9	17.0
	Excess Expected	-1.7	-2.0	-3.7
Site 2 Crashes	Observed	2.0	7.0	9.0
0.1 mi	Predicted	4.2	8.8	13.0
	Expected	2.7	7.0	9.7
	Excess Expected	-1.5	-1.8	-3.3
Site 3 Crashes	Observed	3.0	8.0	11.0
0.14 mi	Predicted	4.0	9.7	13.7
	Expected	3.6	8.5	12.2
	Excess Expected	-0.4	-1.1	-1.6
Site 4 Crashes	Observed	14.0	21.0	35.0
0.25 mi	Predicted	8.2	18.7	26.9
	Expected	10.7	20.3	31.1
	Excess Expected	2.6	1.6	4.2
	EE%	0.3		
Site 5 Crashes	Observed	4.0	10.0	14.0
0.15 mi	Predicted	4.3	10.3	14.6
	Expected	4.0	10.2	14.2
	Excess Expected	-0.3	-0.1	-0.3
Site 6 Crashes	Observed	7.0	11.0	18.0
0.17 mi	Predicted	5.1	11.7	16.7
	Expected	5.1	10.8	15.9
	Excess Expected	0.0	-0.8	-0.9
Site 7 Crashes	Observed	6.0	8.0	14.0
0.42 mi	Predicted	12.9	27.7	40.6
	Expected	9.3	12.9	22.2
	Excess Expected	-3.6	-14.9	-18.5
Project Total Crashes	Observed	40.0	77.0	117.0
1.37 mi	Predicted	45.5	100.8	146.2
	Expected	40.5	81.6	122.2
	Excess Expected	-4.9	-19.1	-24.1

* Excess Expected Crash Frequency:
Positive values indicate ISATe expects higher crash frequencies at the site vs. the model average.